Astronomische Gesellschaft
German Astronomical Society

The 2019 Annual Meeting of the German Astronomical Society

Mission to the Universe
From Earth to Planets, Stars & Galaxies

Stuttgart, 16 – 20 September 2019
https://conference.dsi.uni-stuttgart.de/e/ag2019
#ag2019stuttgart

Invited Speakers include:
Xavier Barcons
Ewine F. van Dishoeck
Heino Falcke
Victoria Grinberg
Rolf Güsten
Günther Hasinger
Frank P. Helmich
Hendrik Hildebrandt
Sabine Klinkner
Pablo Marchant
Katja Poppenhäger
Manami Sasaki
Volker Springel
Else Starkenburg
Andrzej Udalski
Ann Zabludoff

SOC:
Reinhold Ewald
Eva K. Grebel
Andreas Kaufer
Alfred Krabbe
Michael Kramer
Heike Rauer
Eva Schinnerer
Volker Springel
Matthias Steinmetz
Joachim Wambsganß

Public Talk:
Harold Yorke
Yoko Okada

University of Stuttgart
Germany

DSI

IRS

DFG Deutsche Forschungsgemeinschaft

WILHELM UND ELSE HERAEUS-STIFTUNG

Credits: NASA/USRA, ESO, Schlossplatz Neues Schloss by Julian Herzog

Mission to the Universe
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Annual Meeting of the Astronomische Gesellschaft 2019

Stuttgart, September 16-20, 2019

Contents

Should you have any questions related to the conference organisation or need other help, please, feel free to contact the conference office:

Phone: +49 (711) 685-60722
email: ag2019@dsi.uni-stuttgart.de

We wish you an inspiring and productive conference and hope you will enjoy your stay in Stuttgart!

Preamble

Dear colleagues and friends,

a warm welcome to all of you to the 2019 Annual Meeting of the Astronomische Gesellschaft (AG) in Stuttgart with the motto: “Mission to the Universe - From Earth to Planets, Stars & Galaxies”. We are grateful to the Deutsches SOFIA Institute (DSI) at Stuttgart University for hosting this year’s international scientific conference of the AG. Needless to say that SOFIA – the “Stratospheric Observatory for Infrared Astronomy” – is one of the foci of this meeting, both the science achieved with this very particular infrared telescope on board a Boeing 747, AND the airplane/telescope itself: Many of you will have the chance to visit and enjoy the SOFIA airplane at Stuttgart airport.

This year’s meeting is special in a few more aspects: Due to the IAU General Assembly in Vienna last year, there was no scientific AG meeting in 2018. But a number of AG awards were announced in 2018 anyway, so we will have twice as many AG prize talks as usual; since they did not all fit into the Tuesday morning session, we spread them over the whole week. Another unusual aspect of this year’s AG meeting is the location: No living astronomer remembers an annual AG meeting having taken place in Stuttgart! However, there was one before, namely in the year 1871, 148 years ago! Hopefully it does not take about 1.5 centuries for the next AG meeting to take place in this beautiful city!

We look forward to a dense week with very exciting plenary talks in the mornings: topics range from X-ray binaries to supermassive black holes, from the ISM in the LMC to galaxy evolution and cosmic structure formation. You will hear about OGLE, Gaia and SOFIA, and you will have the pleasure to listen to two Karl-Schwarzschild-Lectures (2018 and 2019 Awardees), to an AG scientific software prize talk (2018) and to a team of AG instrumentation prize awardees (2019). In addition there will be two Biermann Awardee talks (2018 & 2019) as well as three AG PhD awardee presentations. Furthermore, the ESO Director General, the ESA Director of Science and the IAU president will give plenary talks.

In the afternoons, 16 splinter meetings will take place, a couple of them spanning even two days. They cover fields ranging from solar activity, star formation, protoplanetary disks and exoplanets to Milky Way and Galactic Archaeology, and also aspects like public outreach, teachers' training and eScience/Virtual Observatory. The public talk (in German: "Blick ins versteckte Universum") on Thursday evening will be given jointly by a German-American and a Japanese astrophysicist, it will be hosted by a Stuttgart astronaut/scientist, the topic are highlights of the flying observatory SOFIA.

We hope you will join us for the conference dinner on Wednesday evening in the world-famous Stuttgart Zoo Wilhelma – it should give you plenty opportunities for exchange with other participants of the meeting. Finally, I would like to thank all members of the Scientific Organising Committee and of the Local Organising Committee for their support and help in organising a very promising meeting, in particular I would like to mention Maja Kaźmierczak-Barthel, Andre Beck and Alfred Krabbe. I wish all of us a very exciting scientific week in Stuttgart with lots of memorable talks, results and personal encounters.

Joachim Wambsganss
President of the Astronomische Gesellschaft

Dear colleagues and guests,

it is my great pleasure to welcome you to the Annual Meeting of the German Astronomical Society. The official host of the meeting, the University of Stuttgart, is one of the most outstanding German research centres, and is at the forefront of science and technology. This applies in particular to the Faculty of Aerospace, which has a long tradition in Stuttgart. The University has developed one of the largest aerospace campuses in Europe with over 2000 students. The German SOFIA Institute (DSI) is proud to have the opportunity to organise such an international conference meeting.

The success of modern astronomical research is largely based on advanced technology and interdisciplinary collaboration. For over a century, the development of large telescopes on the ground, in the air or in space has been driving technology limits. As the latest generations of scientific instruments become increasingly complex, they benefit immensely from advancements in commercial technologies. For example, astronomical detectors profit from recent successes in semiconductor research, micromachining and lithography. Big data in astronomy not only calls for increased computing power, databases and storage capacity, but also requires the development of algorithms based on artificial intelligence to enable the efficient handling and extraction of its huge information content.

The University of Stuttgart is very proud of its tradition of providing an interdisciplinary working environment, enabling researchers from many backgrounds to co-operate in finding novel solutions to complex demands. This is also true for the Institute of Space Systems (IRS), of which the

DSI is a part. Physicists, engineers, technicians, educators and other specialists work together in the design and development of satellites, airborne science experiments, re-entry technology, astronautics and simulations as well as astronomical topics.

SOFIA and the DSI are excellent examples of such interdisciplinary networks, where we strive together to make airborne astronomy a great success. This year we enjoy the presence of SOFIA throughout the conference week, which provides an opportunity for participants to experience this unique aircraft in Germany. It is my pleasure to invite all of you for a visit of this American-German astronomical *Großforschungseinrichtung*.

I wish you a very pleasant conference week, with many constructive discussions, enlightening talks and presentations, new ideas and insights, and inspiring encounters with colleagues and friends.

Alfred Krabbe
Director DSI, SOC Chair

Organizers

Scientific Organizing Committee

- Reinhold Ewald (IRS, U. Stuttgart)
- Eva K. Grebel (ZAH, U. Heidelberg)
- Anreas Kaufer (ESO, Chile)
- Alfred Krabbe (DSI, U. Stuttgart, Chair)
- Michael Kramer (MPIfR, Bonn)
- Heike Rauer (DLR; FU, Berlin; TU, Berlin)
- Eva Schinnerer (MPIA, Heidelberg)
- Volker Springel (MPA, Garching)
- Matthias Steinmetz (AIP, Potsdam)
- Joachim Wambsganß (ZAH, U. Heidelberg, co-Chair)

Local Organizing Committee

- Andre Beck (DSI, U. Stuttgart)
- Stefanos Fasoulas (IRS, U. Stuttgart)
- Janine Fohlmeister (AIP, Potsdam)
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Logistics

Wireless Internet Access
Eduroam is available in every building on the campus. Additionally, there is the possibility to get free internet via

konferenz

Password:	531-672-874-043	16.09.2019
	515-372-198-630	17.09.2019
	570-206-967-961	18.09.2019
	363-619-848-322	19.09.2019
	554-607-889-978	20.09.2019

Please keep in mind that you automatically accept the terms and conditions when using the "konferenz"-network. The terms and conditions can be looked up at the registration desk.

Lunch Options
During the lunch break, from 12:30 to 14:00, you have several options. Each of them is within walking distance and shown in the map of campus (page 200). See below for more information and pictures of the entrances.

- Mensa (straight behind building 47), Pfaffenwaldring 45

- Pokkez (Wraps, 10 min), Pfaffenwaldring 60

- Taverna Elia (Greek, 10 min), Pfaffenwaldring 62

- La Bruschetta (Italian, 10 min), Pfaffenwaldring 62

- Campus.Guest (10 min), Universitätsstraße 34

- Café Eleni (Dish of the day, Coffee and more, 5 – 10 min), Pfaffenwaldring 31

Detailed Program

Lecture Halls

All plenary talks will be held in the *Erich-Feldtkeller-Hörsaal* (47.02), Pfaffenwaldring 47, 70569 Stuttgart. Splinter Sessions are either in Pfaffenwaldring 47 (Rooms 47.02, 47.05, 47.06), or Pfaffenwaldring 9 (Rooms 9.11, 9.12, 9.22, 9.41), which is next to Pfaffenwaldring 47. Locations are shown on the maps in this booklet. In addition, signs in the buildings will guide you. The general nomenclature of lecture rooms is Building DOT Floor Counter. The entrances of Building 47 (left) and Building 9 (right) are shown below.

Monday, 16 September 2019

09:00 - 18:00	**Arbeitskreis Astronomiegeschichte**	
	Planetarium Stuttgart Willy-Brandt-Straße 25	
09:00 - 13:00	**Meeting AG Board (closed session)**	9.02
13:00 - 18:00	**RDS Meeting (closed session)**	29.0.49
13:00 - 16:00	**PhD Students Meeting**	9.11
16:00 - 18:00	**AstroFrauenNetzwerk Get-together**	9.11
18:30 - 20:30	**Welcome Reception**	
	Town Hall, Marktplatz 1	

Tuesday, 17 September 2019

09:00 - 10:00	**Opening & Award Ceremonies** Opening: *Prof. Dr. Joachim Wambsganß* (President of the Astronomical Society) Welcome Addresses: Dr. Simone Schwanitz *(Deputy Minister MWK)* Prof. Dr. Dr. h.c. Wolfram Ressel *(Rector University of Stuttgart)* Prof. Dr. Volker Schwieger *(Dean Faculty of Aerospace Engineering and Geodesy)* Prof. Dr. Stefanos Fasoulas *(Director IRS)*	47.02
10.00 - 10:30	**Plenary Talk** Karl Schwarzschild Prize Talk 2018 - *Andrzej Udalski* - The OGLE Sky Variability Survey	47.02
10:30 - 11:00	**Coffee Break & Poster Session**	Foyer 47
11:00 - 12:30	**Awards and Plenary Talk**	47.02
11:00 - 11:30	Astronomical Software Prize Talk 2018 *Volker Springel* - Simulating cosmic structure formation	
11:30 - 12:00	Instrumentation Award Talk - *Erik Høg, Lennard Lindegren, Michael Perryman* - The road from meridian circles to Gaia and beyond	
12:00 - 12:30	Awards: Bruno-H.-Bürgel *(Johannes Feitzinger)*, Jugend forscht, Hanno und Ruth Roelin *(Sibylle Anderl)*	
12:30 - 14:00	**Lunch Break**	

14:00 - 15:00	**Splinter Meetings**	
EScience	EScience and Virtual Observatory 1 (p. 41)	9.11
Exoplanets	From Protoplanetary Disks to Exoplanets 1 (p. 51)	9.41
OGLE	OGLE-ing the Variable Sky (p. 55)	9.22
Solar Activity	Solar Activity (p. 65)	9.12
Spectroscopy	New Challenges in Stellar Spectroscopy 1 (p. 72)	47.06
Star Formation	Star Formation and Stellar Feedback (p. 78)	47.05
15:10 - 15:40	**Coffee Break & Poster Session**	Foyer 47
15:50 - 18:30	**Splinter Meetings**	
EScience	EScience and Virtual Observatory 1	9.11
Exoplanets	From Protoplanetary Disks to Exoplanets 1	9.41
OGLE	OGLE-ing the Variable Sky	9.22
Solar Activity	Solar Activity (until 17:00)	9.12
Spectroscopy	New Challenges in Stellar Spectroscopy 1	47.06
Star Formation	Star Formation and Stellar Feedback	47.05
17:00 - 19:00	**92. Mitgliederversammlung der Astronomischen Gesellschaft**	47.02

Wednesday, 18 September 2019

08:00 - 18:30	**Training of Teachers**	29.01
09:00 - 10:30	**Plenary Talks**	47.02
09:00 - 09:30	*Rolf Güsten* - First Astrophysical Detection of the Helium Hydride Ion (HeH+)	
09:30 - 10:00	*Manami Sasaki* - What makes the Large Magellanic Cloud so special: the multiphase interstellar medium	
10:00 - 10:30	*Victoria Grinberg* - X-ray binaries as universal tools of astrophysics	
10:30 - 11:00	**Coffee Break & Poster Session**	Foyer 47
11:00 - 12:30	**Plenary Talks**	47.02
11:00 - 11:30	*Frank Helmich* - The infrared science and instrumentation lineage in the Netherlands - building towards SPICA	
11:30 - 12:00	*Katja Poppenhäger* - Understanding the evolution of star-planet systems	
12:00 - 12:30	*Xavier Barcons* - The ESO Programme	
12:30 - 14:00	**Conference Photo & Lunch Break**	

14:00 - 15:00	**Splinter Meetings**	
Early MW	The early Milky Way as seen through Galactic Archaeology 1 (p. 93)	47.05
EScience	EScience and Virtual Observatory 2 (p. 100)	9.11
Exoplanets	From Protoplanetary Disks to Exoplanets 2 (p. 101)	9.41
Maser	Cosmic Masers (p. 107)	9.12
SOFIA	SOFIA measurements of Nearby Galaxies and the CMZ of the Milky Way (p. 118)	47.02
Spectroscopy	New Challenges in Stellar Spectroscopy 2 (p. 133)	47.06
15:10 - 15:40	**Coffee Break & Poster Session**	Foyer 47
15:50 - 18:30	**Splinter Meetings**	
Early MW	The early Milky Way as seen through Galactic Archaeology 1	47.05
EScience	EScience and Virtual Observatory 2	9.11
Exoplanets	From Protoplanetary Disks to Exoplanets 2	9.41
Maser	Cosmic Masers	9.12
SOFIA	SOFIA measurements of Nearby Galaxies and the CMZ of the Milky Way	47.02
Spectroscopy	New Challenges in Stellar Spectroscopy 2	47.06
19:15 - 22:30	**Conference Dinner**	
	Marché Mövenpick, Neckartalstr., 70376 Stuttgart	

Thursday, 19 September 2019

08:45 - 13:30	**Training of Teachers**	29.01
09:00 - 10:30	**Plenary Talks**	47.02
09:00 - 10:00	Karl Schwarzschild Prize Talk - *Ewine van Dishoeck* - Molecules from clouds to disks and planets	
10:00 - 10:30	Ludwig Biermann Prize Talk 2018 - *Else Starkenburg* - Galactic archaeology to its limits	
10:30 - 11:00	**Coffee Break & Poster Session**	Foyer 47
11:00 - 12:30	**Plenary Talks**	47.02
11:00 - 11:30	*Ann Zabludoff* - Hearts of Darkness: Surprising Links between Supermassive Black Holes and Galaxy Evolution	
11:30 - 12:00	PhD Prize Talk - *Tim Lichtenberg & Oliver Friedrich* - Thermal Evolution of Forming Planets & Do we understand gravitation on cosmological scales	
12:00 - 12:30	*Günther Hasinger* - Exploring the Universe: Synergies in the ESA Science Programme	
12:30 - 14:00	**Lunch Break**	

14:00 - 15:00	**Splinter Meetings**	
Computational	Computational Astrophysics (p. 140)	47.02
Early MW	The early Milky Way as seen through Galactic Archaeology 2 (p. 149)	47.05
Education	Astronomy and Education (p. 157)	9.11
Future	Future Astronomical Opportunities in Stratosphere and Space (p. 162)	9.41
Outreach	Outreach Meeting	29.0.49
Polarimetry	Cosmic Dust and Spectral Line Polarization as Analytical Tools (p. 171)	9.12
15:10 - 15:40	**Coffee Break & Poster Session**	Foyer 47
15:50 - 18:30	**Splinter Meetings**	
Computational	Computational Astrophysics	47.02
Early MW	The early Milky Way as seen through Galactic Archaeology 2	47.05
Education	Astronomy and Education	9.11
Future	Future Astronomical Opportunities in Stratosphere and Space	9.41
Outreach	Outreach Meeting	29.0.49
Polarimetry	Cosmic Dust and Spectral Line Polarization as Analytical Tools	9.12
20:00 - 21:30	**Public Talk** (p. 179)	
	Hospitalhof, Büchsenstraße 33, 70174 Stuttgart	

Friday, 20 September 2019

09:00 - 10:30	**Plenary Talks**	47.02
09:00 - 09:30	*Ewine van Dishoeck* - IAU 100 years	
09:30 - 10:00	*Hendrik Hildebrandt* - Challenges in current weak lensing surveys for cosmology	
10:00 - 10:30	PhD Prize Talk 2018 - *Pablo Marchant* - Where do stellar-mass merging binary black holes come from?	
10:30 - 11:00	**Coffee Break & Poster Session**	Foyer 47
11:00 - 12:00	**Plenary Talks**	47.02
11:00 - 11:30	*Sabine Klinkner* - The Flying Laptop platform and its potential for astronomy missions	
11:30 - 12:00	*Heino Falcke* - Imaging Black Holes with the Event HorizonTelescope	
12:00 - 12:10	**Closing**	

Plenary Talks

The OGLE Sky Variability Survey

The largest observing program in the history of the Polish astronomy – The Optical Gravitational Lensing Experiment (OGLE) is conducted by the astronomers from the Astronomical Observatory of the University of Warsaw and since its beginning in 1992 it has always belonged to the largest sky surveys worldwide. Throughout its almost three-decade history the OGLE survey has been continuously bringing scientific discoveries of the highest level. The OGLE project set the new research fields in modern astronomy by pioneering new ways of conducting observations – long-term monitoring of large areas of the sky and developing the so called time domain astrophysics. The most important results of the OGLE survey include the first detection of gravitational microlensing events and the development of this new field of research in astronomy. The phenomenon of gravitational microlensing was used, among others, to study the dark matter in the Milky Way and the analysis of its structure, as well as to a search for extrasolar planets. Another breakthrough discoveries have been made in the search for exoplanets. For the first time, the OGLE project successfully implemented two new techniques of exoplanet detection: the method of transits, and gravitational microlensing. So far, over 80 extrasolar planets have been discovered. The OGLE project created the world's largest collection of well characterized periodic variable stars – consisting currently of about one million objects. It contains many unique objects including new, previously unknown types of variable stars. The project regularly discovers eruptive objects – novae, dwarf novae, supernovae and other types of transient objects. The OGLE discovered variable stars are the base of the cosmic distance scale and studies of the history and evolution of the Milky Way and the Magellanic Clouds. During the lecture the main older and recent achievements of the OGLE survey will be presented.

Primary author(s): UDALSKI, Andrzej

Simulating cosmic structure formation

Numerical simulations of cosmic structure formation have proven instrumental for understanding the out-come of the initial conditions left behind by the Big Bang. Nowadays, they are not only accurately predictingthe dark matter backbone of the cosmic web and the internal structure of halos and their satellites far intothe non-linear regime, but are also following the baryonic sector with rapidly improving physical fidelity. Inmy talk, I will review the methodology and selected successes of simulations of cosmic structure formation,focusing on recent hydrodynamical calculations of galaxy formation and evolution. According to these models, the role played by strong, scale-dependent feedback processes from supernovae and supermassive blackholes could hardly be overstated. I will critically discuss some of the primary uncertainties in modelling theseprocesses, and consider a number of the challenges lying ahead in this field in the coming years.

Primary author(s): SPRINGEL, Volker (MPA)

The road from meridian circles to Gaia and beyond

As student of 21 years in 1953 I began to work at the new meridian circle at Brorfelde located 50 km from Copenhagen. I became fascinated by the instrument and saw the great importance of astrometry for astronomy and astrophysics. But when I arrived in 1958 as stipendiary at the Hamburg Observatory I wanted to become an astrophysicist joining the dominating stream in astronomy and I started work with spectra from the big Schmidt. In 1960 however, I proposed a new method of astrometry by photon counting, using a photo-multiplier as detector and the then novel electronic computers for data reduction. The idea fitted well with plans for an expedition with the Hamburg meridian circle to Perth in Western Australia and I implemented the new method 1960-67 on the instrument thus returning to astrometry!
The new method was adopted by Pierre Lacroute in France in his design 1964-74 of a scanning satellite. Pierre Lacroute became the father of space astrometry. I considered however his design to be quite unrealistic. In 1975 I was asked to join an ESA study group on space astrometry and could then make a new realistic design which became basis for the Hipparcos satellite launched in 1989.
During the Hipparcos mission I became engaged with Soviet-Russian colleagues who had several plans for a Hipparcos successor. Lennart Lindegren had contributed greatly to Hipparcos since 1976 and now also to these discussions. In 1992 I proposed a new mission called Roemer which would be 100 000 times more efficient for astrometry than Hipparcos thanks to the use of CCDs in Time-Delayed Integration. The Roe-mer proposal for an ESA mission in 1993 was well received by the AWG but was referred to a cornerstone mission if higher accuracy could be obtained. The cornerstone we got with Gaia launched in 2013. Also in 2013, I proposed a Gaia successor for launch about 2035 in order to improve the astrometric foundation of astrophysics. Now we are focusing on an option with NIR capability in order to penetrate obscured regions and to reach red stars. With partners in Europe, USA, Japan and Australia we propose to ESA in Hobbs+2019 arXiv:1907.12535 that GaiaNIR be studied.

Primary author(s): HØG, Erik (Niels Bohr Institute, Blegdamsvej 17, 2100 Copenhagen Ø, Denmark)

First Astrophysical Detection of the Helium Hydride Ion (HeH+)

The helium hydride ion, HeH+, has been detected in space for the first time with the GREAT spectrometer onboard the SOFIA. Through observations of its fundamental rotational transition at 2.010 THz, HeH+ was detected toward the young planetary nebula NGC 7027. This detection brings a decades-long search to a successful conclusion. I will review the history of the study of HeH+, from its discovery in the laboratory almost a century ago to its recognition in the late-1970s as a potentially-detectable astrophysical molecule, and its role as the first molecular bond that formed when, 13 billion years ago, falling temperatures in the young Universe allowed recombination of the light elements produced in the Big Bang. At that time, according to models for the Early Universe, ionized hydrogen and neutral helium atoms reacted to form HeH+. The details of the SOFIA observations will be presented, and the implications of the measured line intensities will be considered in the context of astrochemical models. Follow-up studies toward other sources and through observations of other spectral lines will be discussed briefly.

Primary author(s): GUESTEN, Rolf (MPIfR)

What makes the Large Magellanic Cloud so special: the multi-phase interstellar medium

The Large Magellanic Cloud (LMC) is the largest satellite galaxy of the Milky Way with a large number of young stars, bright HII regions, supernova remnants, and superbubbles. In particular, it hosts the giant HII region 30 Doradus, which is powered by the massive star cluster R136. The distribution of the cold atomic gas in the LMC is known to form two major components, with 30 Doradus being located at a region in which the two HI components interact with each other. South of 30 Doradus, a large ($\sim$ 1 kpc) X-ray emitting structure called the X-ray spur has been discovered. This X-ray emission appears to be anti-correlated with the colliding HI gas components. We study the different phases of the interstellar medium in the LMC to investigate the origin and the evolution of the different intriguing interstellar structures and their impact on star formation.

Primary author(s): SASAKI, Manami

X-ray binaries as universal tools of astrophysics

Binaries consisting of a neutron star or a black hole that accretes matter from a stellar companion are the brightest sources in the X-ray sky. These X-ray binaries are highly dynamic, with variability scales ranging from millisecond quasiperiodic oscillations and hour- and day-long orbital periods to year-long activity cycles. They change not merely in brightness, but in the very physical processes that cause the X-ray emission. I will show that X-ray binaries are among the most important objects of today's astrophysics. In particular, I will address how we can use X-ray binaries as unique labs to probe the physics of extreme gravity to understand accretion onto black holes of all masses and how X-ray binaries can crucially contribute to the understanding of the wind structure and thus evolution of the most massive stars in our universe.

Primary author(s): GRINBERG, Victoria (IAAT/Universität Tübingen)

The infrared science and instrumentation lineage in the Netherlands - building towards SPICA

SPICA is one of the three candidates for the 5th slot for medium sized missions (M5) in the Cosmic Vision Program of the European Space Agency. SPICA will have an actively cooled (order 6K) telescope, which suppresses the background down to the natural backgrounds resulting from a.o. the zodiacal light. SPICA has therefore an unprecedented deep view on our Universe and is able to spectroscopically analyse large numbers of galaxies down to a redshift of about 4. This will give us characteristics of the evolution of the Interstellar Medium over a large part of Cosmic Time, when star formation was at its peak and will show us virtually all AGN activity over that same period. SPICA, as an observatory, will contribute to almost all fields of astronomy. The Netherlands has played an important role in the development of far-IR instrumentation, from the Infrared Space Observatory to Herschel and SPICA. I will highlight this with science and technology examples.

Primary author(s): HELMICH, Frank (SRON)
Co-author(s): ROELFSEMA, Peter (SRON)

Understanding the evolution of star-planet systems

Stars and their exoplanets evolve together over billions of years, just like our own solar system. Many known exoplanetary systems have planets orbiting their host stars at much closer distances than we observe in the solar system, with orbital periods of only a few days. In such systems one expects the star and its close-in planet to interact through tidal and magnetic forces, tying their evolution together. These interactions can give us insights into fundamental properties of star- planet systems which are hard to constrain otherwise: the time scale over which close-in planets spiral into the star, the evolution of stellar activity, and the amount of atmospheric evaporation and the habitability for all planets in a system with a close-in planet. Gaia and other telescopes have now opened up new pathways to measure how stars and planets interact with each other. I will present new approaches to test for planet-induced influences on stars through wide binary systems, motivate a new look at stellar magnetic activity measurements, and discuss how planetary atmospheres can evaporate over the lifetime of exoplanets.

Primary author(s): POPPENHÄGER, Katja (AIP)

The ESO Programme

ESO is de facto the lead world-wide organisation in building and operating most powerful groundbased astronomical observatories. The success of the organisation relies on the support of its member states and the cooperation with the community, among other ket factors. ESO facilities are structured in terms of Programmes, currently: La Silla Paranal and ALMA (both in operation), ELT (in construction) and CTA-S (under design by CTAO). I will review the current status and future prospects of these programmes, emphasising science and instrument development opportunities in the coming years.

Primary author(s): BARCONS, Xavier (ESO)

Molecules from clouds to disks and planets

The discovery of thousands of planets around stars other than our Sun has revived age-old questions on how these exo-planets form and which chemical ingredients are available to build them. Star formation and chemistry start in the cold and tenuous clouds between the stars. In spite of the extremely low temperatures and densities, these clouds contain a surprisingly rich and interesting chemistry, as evidenced by the detection of more than 200 different molecules. New facilities such as ALMA and soon JWST allow us to zoom in on dense cloud cores and planetary system construction sites with unprecedented sharpness and sensitivity, revealing a wide range disk structures. Spectral scans of young disks contain tens of thousands of rotational lines, revealing water and a surprisingly rich variety of organic material. How are these prebiotic molecules formed and can they end up on new planets?

Primary author(s): VAN DISHOECK, Ewine F. (Leiden Observatory, Leiden University, the Netherlands)

Galactic archaeology to its limits

There is much to be learned about galaxy formation and evolution from our own Milky Way halo and the dwarf galaxies around it. Resolved stellar spectroscopy presents us with "archaeological" evidence about the chemical enrichment of the interstellar medium back to the earliest times. In this talk I will review several insights in the (chemical) evolution of the dwarf galaxies around the Milky Way from both modeling and observational perspectives. In particular, I will focus on studying the earliest history of the Milky Way, as imprinted in the oldest and most metal-poor stars.

Primary author(s): STARKENBURG, Else (AIP)

Hearts of Darkness: Surprising Links between Supermassive Black Holes and Galaxy Evolution

While astronomers are working hard to detect the earliest galaxies and to follow their evolution, we remain baffled by the present-day dichotomy between disky, star forming galaxies and quiescent, spheroidal galaxies. The key is to find galaxies in transition from one class to the other, whose spectra indicate intense recent star formation that has now ended. We have identified thousands of such "post-starburst galaxies" whose current kinematics, stellar populations, and morphologies are consistent with late- to early-type galaxy evolution. I will discuss recent work that suggests new connections between their violent merger history and the central supermassive black hole. For example, the molecular gas reservoir of a post-starburst galaxy declines rapidly after the starburst ends and in a manner consistent with feedback from an active nucleus. Furthermore, a star is 300x more likely to be tidally disrupted by the nucleus of a post-starburst galaxy than in other galaxies. Like the well-known black hole-bulge mass correlation, these surprising links between the properties of a galaxy on kpc scales and its nucleus on pc scales require explanation.

Primary author(s): ZABLUDOFF, Ann (University of Arizona)

Thermal Evolution of Forming Planets: Isotope Enrichment, Differentiation & Volatile Retention

Because astronomical observations are ultimately limited in providing a complete picture of the exoplanetary census, a comprehensive understanding of planetary systems' formation and evolution can deliver valuable insights into key physical and chemical properties that cannot be probed by remote sensing alone. Here, I will discuss how the inhomogeneous enrichment of protoplanetary disks with short-lived radionuclides, namely Al-26 and Fe-60, in typical star-forming environments controls the interior evolution and volatile loss of planetesimals that accrete to form terrestrial planets. I derive the primary thermochemical regimes for the build-up of internal magma oceans, core segregation, chemical differentiation, and volatile retention. I demonstrate how matching planetesimal interior evolution with meteoritic evidence constrains the accretion dynamics and reprocessing of planetary materials in the early Solar system. Extrapolating the derived mechanisms to the exoplanet population, I demonstrate the primary influence of short-lived radionuclides on the efficiency of volatile delivery to terrestrial planets: enriched systems with Solar-like or higher levels tend to form water-depleted planets, while not- or barely-enriched systems dominantly form ocean worlds. These results provide a direct link between the star-forming birth environment of planetary systems and the compositional make-up and long-term evolution of rocky planets that form in them: the system-to-system deviations in the abundance of short-lived radionuclides across young star-forming regions qualitatively distinguish planetary systems' formation and evolution, and control the distribution and prevalence of terrestrial planets with Earth-like bulk compositions.

Primary author(s): LICHTENBERG, Tim (University of Oxford)

Do we understand gravitation on cosmological scales?

The Cosmic Microwave Background contains information about the amplitude of density fluctuations in the early universe, while the cosmic web of structures around us informs us about the amplitude of density fluctuations today. Comparing these two snapshots of the Universe's evolution we can ask: Does our theory of gravitational collapse correctly reproduce the observed growth of structures? I will report on a number of studies that try to answer this question.

Primary author(s): FRIEDRICH, Oliver (Kavli Institute for Cosmology Cambridge)

Exploring the Universe: Synergies in the ESA Science Programme

Science is THE underpinning theme of ESA. As the motor of the spiral of inspiration, innovation, information exchange and interaction (I^4) with the Agency's stakeholders, science is a key unifying theme of the Agency's activities. Basic science drives innovation and therefore technological advances, leading to progress and economic development. It drives inspiration and thus the fascination and education of new generations of scientists and engineers. It drives information exchange and communication with the general public that in the end as taxpayers fund the Agency. And it drives the interaction among scientists, with international partners and with stakeholders, ultimately leading to new projects and the next turn of the I^4-spiral. Starting from recent discoveries in astrophysics and space science I give a comprehensive summary of the ESA Science Programme and the strategic development plans for the future. In particular I will give examples of important synergies between different ESA Science missions.

Primary author(s): HASINGER, Günther (ESA Director of Science)

Celebrating IAU 100 years

In 2019, the International Astronomical Union (IAU), the organization of all professional astronomers worldwide, commemorates its foundation a century ago. This is an opportunity to celebrate more broadly the progress in astronomy over the past hundred years and what our field has brought to society, but also to look ahead and reflect critically on IAU's role for decades to come. Looking back, scientific and technological progress in astronomy has been beyond anything imagined at the time the IAU was constituted in 1919.

What will the next hundred years bring? How do we engage with other sciences, now that our field is becoming more multidisciplinary? How do we convince governments and agencies to continue funding our field, in particular the ever more powerful telescopes? And how do we inspire and involve people worldwide, from young to old, in our exciting adventure through space?

This talk will present some highlights of the past century as well as a forward look how the IAU is positioned to carry out its mission: to promote and safeguard astronomy in all its aspects (including research, communication, education and development) through international cooperation.

Primary author(s): VAN DISHOEK, Ewine F. (IAU President, Leiden University, the Netherlands)

Challenges in current weak lensing surveys for cosmology

Weak gravitational lensing of the large-scale-structure of the Universe has been established as one of the most promising observational probes of cosmology for the next decade. Three large imaging surveys (so called stage-III surveys) - the Dark Energy Survey, Hyper-Suprime Cam, and the Kilo-Degree Survey - are currently pushing this field to the next level of precision and systematic error handling. In this talk I will review the state-of-the-art in the field, the main technical challenges, and present results from all three surveys. I will compare those results to each other as well as to other cosmological probes and highlight some interesting differences that are hotly debated at the moment. I will also give an outlook to the upcoming stage-IV surveys Euclid and LSST, and summarise the most important technical innovations that still need to happen before these surveys can reach their full potential.

Primary author(s): HILDEBRANDT, Hendrik (Astronomisches Institut, Ruhr-Universität Bochum)

Where do stellar-mass merging binary black holes come from?

In the last few years, the field of gravitational wave astrophysics has quickly grown, with current ground-based detectors observing an event almost every week. As detections accumulate, these sources will helpus constrain multiple physical processes occurring in their progenitor stars. In this talk I will discuss one ofthe proposed theoretical channels for the formation of merging binary black holes, which involves efficientmixing induced by rotation in close binary stars. This process can also lead to the formation of transientsources such as long-gamma ray bursts and pair instability supernovae, as well as persistent ultra-luminous X-ray sources, allowing for further observational tests with electromagnetic observations.

Primary author(s): MARCHANT, Pablo (Argelander-Institut für Astronomie)

The Flying Laptop platform and its potential for astronomy missions

The talk will give an introduction of the Flying Laptop mission and its flight proven satellite bus. Furthermore it will show the potential - and limits - of small satellite systems for astronomy missions.

Primary author(s): KLINKNER, SABINE (Institut für Raumfahrtsysteme, Universität Stuttgart)

Imaging Black Holes with the Event Horizon Telescope

One of the most fundamental predictions of general relativity are black holes. Their defining feature is the event horizon, the surface that even light cannot escape. When illuminated by ambient light, the event horizon of black holes will cast a dark shadow on the emitting region that is detectable under certain circumstances with global interferometers operating at mm- and submm- wavelengths. Recently the Event Horizon Telescope has detected this shadow feature in the radio galaxy M87, providing a first glimpse at scales surrounding the event horizon. Models invoking general relativity and magnetized plasma hydrodynamics are able to reproduce the appearance of the shadow and of the powerful jet launched at these scales. This provides strong support for the existence of supermassive black holes in the universe and sheds light on how they work. To improve the imaging quality further more telescopes should be added to the array, in particular in Africa. The more distant future will belong to higher frequencies and space-based interferometry. The talk will review the latest results of the Event Horizon Telescope, its scientific implications and future expansions of the array.

Primary author(s): FALCKE, Heino (Radboud University)

Splinter Meetings

Tuesday 17 September

EScience and Virtual Observatory - Part 1

Room 9.11
Content: The importance of publicly available and accessible astronomical data sets for the feasibility and effectiveness of research in astronomy and astrophysics has been shown many times in the past years. From last year, perhaps the most spectacular example is the flood of results employing data release 2 of Gaia, facilitated at least in part by a well-designed, Virtual Observatory-based data dissemination and query infrastructure.

New instruments coming online in the next few years, from Euclid to SKA to LSST, will still require significant evolution as well as development of new methods to enable similar science success stories.

This is not merely a question of publication techniques. It also involves application machine learning, computational statistics or neural networks. Software development for astronomical machinery, for instrument data pipelines, and analysis of data still call for new approaches.

Providing suitable tools and research environments aiding scientists in essentially all fields of astronomy is a central part of astronomical research infrastructure. It will certainly only become more important, as will data management, data access, and data publication. This was recognised by the GWK initiating the NFDI (Nationale Forschungsdaten-Infrastruktur) program. Sharing the lessons learnt in astronomy and exploiting the promises of cross-disciplinary technology development using this platform will therefore be on the agenda for next years.

We invite you to share your experiences and ideas, learn from successful applications, and discuss problems, obstacles and challenges of publishing and exploiting both large and diverse data in our science. We specially call for contributions to a session: “Demonstrate your favorite software/tool for doing astronomy!”

From Photometric Redshift to Improved Weather Forecasts

Machine learning has become a key tool in analysing complex and large datasets in many disciplines. Many of the used machine learning algorithms are applicable to different problems and one can learn from examples and techniques used in different science domains. In this talk, an interdisciplinary exchange between postprocessing of weather forecasts, photometric redshift estimation in astronomy, and back to weather forecasting is presented.

Primary author(s): POLSTERER, Kai (HITS gGmbH); D'ISANTO, Antonio (HITS gGmbH); LERCH, Sebastian (KIT)

Can crowdsourcing be replaced by GPUs?

Radio observations provide an extremely valuable insight into our Universe. With upcoming surveys such as EMU, the amount of data in the radio regime will further increase by an estimated factor of 30. In order to analyze this vast amount of data, innovative machine learning methods are needed. In light of this, we propose a semi-automated algorithm that provides an initial analysis and classification of the data to aid astronomers. We produce a map of the morphologies present in the data. This map is then manually annotated with classes whose boundaries are interpreted only in a soft manner, giving rise to a probabilistic schema. Our technique is able to differentiate the sources with respect to their structure and complexity, e.g. point-like, extended, etc. We perform several experiments using radio data and describe their results. Furthermore, we analyze infrared counterparts of the radio sources. This allows our morphological schema to include information about the location of the central component of the sources, further improving the classification of the radio source. We also demonstrate that many tasks currently done by human volunteers can be automated, leaving only the more complex and interesting objects for humans.

Primary author(s): HOPKINS, Erica (HITS gGmbH); POLSTERER, Kai (HITS GgmbH)

Galactic Archeology with RAVE and APOGEE using Convolutional Neural Networks

One of the goals of current spectroscopic surveys is to provide precise chemical abundances of stellar populations in order to constrain the formation and evolution of our Galaxy, the Milky Way. In this talk, I will present how a Convolutional Neural Network can be used to retrieve robust chemical diagnostic from the RAVE survey, using APOGEE as training dataset. I will also show the gain in precision achieved withrespect to current chemical pipelines.

Primary author(s): GUIGLION, Gillaume (AIP)

Artifact detection on photographic plates with convolutional neural networks

Reliable extraction of sources from digitized photographic plates is more complicated than when images are recorded using a CCD camera. Due to the fragile nature and age of the plates they are subject to several effects that act as a source of false-positive detections. Among these effects are surface dust speckles, scratches, emulsion damage etc. Besides those, the optical systems used to acquire the images come with their share of aberrations which make the removal of false-positives even harder. The APPLAUSE database already consists of a few billion detections, many of which are not actual astrophysical sources. Their removal is very important for practical purposes but is not a trivial task. We will present a convolutional neural network based pipeline that is able to detect the artifacts and is capable of assigning false-positive probability to individual sources in less clear-cut cases. Our plan is to use its output for improving the calibrations in the next APPLAUSE data release.

Primary author(s): MATIJEVIC, Gal (AIP)

Applausequery - a PyVO application for highlevel access to astronomical photoplate database

The Virtual Observatory (VO) provides many different datasets and services for using the data. The table access protocol (TAP) in combination with the astronomical data query language (ADQL) represent a generic way to access data. Interactice tools like TOPCAT, using TAP and ADQL offer a very flexible way for single requests to the VO. However, in case of repeated requests to the VO, e.g. for comparing some features of thousands of astronomical sources, one needs a programmable interface. As Python with astropy became one of the most important environments for astronomical data analysis, the astropy affiliated package PyVO, which among others supports TAP/ADQL, is a good choice for VO access as it integrates well with that environment. We use the Archives of Photographic PLates for Astronomical USE (APPLAUSE) for research on photometric long term variability. As APPLAUSE provides a TAP service and our needs are many similar queries, e.g. searching for light curves of different sources or getting calibration information, we created the Python package applausequery, which uses PyVO to build the abstraction layer for different common database queries. We present the structure of the package as well as some applications, demonstrating how PyVO can be used as a base for modules supporting specific VO services. This serves as an example for both data providers and scientists on how to improve the scientific workflow by implementing well standardized techniques. We encourgage data providers to offer standardized services like TAP to support scientists in enabling the usage of powerful VO tools like PyVO and in best case, providing more specialized modules like applausequery adapted to scientific use cases.

Primary author(s): DERSCH, Christian (Philipps-Universität Marburg)
Co-author(s): SCHRIMPF, Andreas (Philipps-Universität Marburg)

The IVOA Provenance standard for astrophysical data

In a data driven science like astrophysics, provenance information plays a crucial role to trace back to the origin of a given dataset. Being one of the basic principles of FAIR (R1.2), it is an important prerequisite to reproduce a scientific result. Standardizing the provenance data model by the International Virtual Observatory Alliance (IVOA) enables interoperable implementations to store, access, communicate, and present provenance data in astrophysics. We will describe the upcoming standard and show reference implementations for MuseWISE and APPLAUSE.

Primary author(s): STREICHER, Ole (AIP)

Reducing Bottlenecks in TAP Cross-Server Queries

Today, many astronomers use IVOA's Table Access Protocol TAP to query remote databases. Many of them use the upload facility, which lets them include data residing on the client system in the remote queries. Far fewer researchers are aware that when integrating data from different TAP services, there is (usually) no need to take the detour of first downloading data from one service to the local system and then uploading it to the other, as TAP uploads have been designed to let users directly transfer query results from one TAP server to another. This talk will discuss the (simple) basic idea and show how to use this feature both using STILTS and pyVO. It will conclude with a discussion of (current) limitations and ideas on how to overcome them.

Primary author(s): DEMLEITNER, Markus (Universität Heidelberg, Astronomisches Rechen-Institut)

ESCAPE: building the infrastructure for the next generation astronomy

The data explosion in astronomy requires the development of new techniques both from the infrastructure side and from the analysis side. In particular, the increase of the data complexity demands a parallel effort to deliver efficient and standardized solutions for accessing and managing data, tools and software. The aim of the ESCAPE project is to build a huge European collaboration to face the new challenges given by data-driven research, complex data workflows, infrastractural issues, data and software interoperability. The final goal is to deliver a new platform which could extend the concept of VO, combining data, software and expertise in an open-source repository that looks toward the approaching exabyte-era. In this talk I will give an overview of the first results obtained within the ESCAPE project, introducing the results and the challenges of the first months of work and the next planned steps ahead. I will put particular focus on the problem of dimensionality reduction and visualization of spectra with an autoencoder. I will also point out some problems which can arise in the process of data access, in order to answer a fundamental question: are we ready for machine learning and big data in astronomy?

Primary author(s): D'ISANTO, Antonio (HITS gGmbH)

Transient alert processing and analysis using AMPEL

Multi-messenger astronomy and new high-throughput wide-field surveys require flexible tools for the selection and study of astrophysical transients. We here introduce a streaming data analysis framework named AMPEL (Alert Management, Photometry and Evaluation of Lightcurves). AMPEL's modular design enables user contributed units to run on live data during processing. Units can filter alerts, calculate new transient properties and submit requests for external review or follow-up observations. The embedding framework encourages provenance and records the varying information states that a transient displays. The state concept includes information gathered over time, but also tracks varying data access levels and e.g. improved calibration. AMPEL can ingest information from different alert streams and broker this to a variety of online resources.

After introducing AMPEL, we will discuss lessons learned from reprocessing the first year of Zwicky Transient Facility (ZTF) alerts and describe the real-time publication of ZTF supernova candidates to the TNS. Finally, we will show how anyone can use AMPEL for analysing the ZTF alert stream.

Primary author(s): BRINNEL, V. (DESY)

From Protoplanetary Disks to Exoplanets - Part 1

Room 9.41

Content: The formation of stars and their planetary systems are among the key questions in science. Only by addressing these fundamental questions, we can hope to unravel whether solar systems like ours are common and how many Earth-like planets our Galaxy may harbor. In recent years substantial progress in this direction has been achieved thanks to a powerful combination of high-resolution, high-sensitivity observations aided by detailed theoretical modeling and laboratory studies. The composition and properties of exoplanetary atmospheres are now becoming routinely accessible thanks to the high-resolution coronographic or spectroscopic observations from the ground and space. The diversity of observed exoplanets and their atmospheric composition suggests a tight link between exoplanets and the properties of their pre-natal environments, protoplanetary disks. From the optical to the (sub-)millimeter, observations provide strong evidence for the ongoing planet formation and the presence of planets in their pre-natal environments, protoplanetary disks.

The goal of the AG 2019 splinter meeting entitled ”From protoplanetary disks to exoplanets - the story of their formation” is to bring together the German astrophysical community studying exoplanets, planet formation, and protoplanetary disks. Beside summarizing the status of the field in several lectures and presenting the latest, most interesting results, the organizers hope to stir the discussions and exchange of ideas within our diverse research field. Key scientific topics include (but are not limited to):

- What are the physics and chemistry of planet-forming disks? How do these disks evolve?
- What are the conditions under which planets form?
- Which processes shape the properties of planets and their atmospheric compositions?
- Is our solar system unique or common?
- Which processes do we have to test (and exclude) in order to identify the imprints of planets on disks?
- Might other processes (such as magnetic fields) solve the chicken-and-egg problem of planet formation?

Modeling the Formation of super-Earth Atmospheres

In the core accretion paradigm of planet formation, gas giants form a massive atmosphere in a runaway gas accretion phase once their progenitors exceed a threshold mass: the critical core mass. On the one hand, the majority of observed exo-planets, being smaller and rock/ice-dominated, never crossed this line. On the other hand, these exo-planets have accreted substantial amounts of gas from the circumstellar disk during their embedded formation epoch. We investigate the hydrodynamical and thermodynamical properties of proto-planetary atmospheres by direct numerical modeling of their formation epoch. Our studies cover one-dimensional (1D) spherically symmetric, two-dimensional (2D) axially symmetric, and three-dimensional (3D) hydrodynamical simulations with and without radiation transport. We check the feasibility of different numerical grid geometries (Cartesian vs. spherical), perform convergence studies, and scan the physical parameter space with respect to planet mass and optical depth of the surrounding. In terms of hydrodynamic evolution, no clear boundary demarcates bound atmospheric gas from disk material in a 3D scenario in contrast to 1D and 2D computations. The atmospheres denote open systems where gas enters and leaves the Bondi sphere in both directions. In terms of thermodynamics, we compare the gravitational contraction of the forming atmospheres with its radiative cooling and advection of thermal energy, as well as the interplay of these processes. The coaction of radiative cooling of atmospheric gas and advection of atmospheric-disk gas prevents the proto-planets to undergo run-away gas accretion. Hence, this scenario provides a natural explanation for the preponderance of super-Earth like planets. Additionally, we will show preliminary results on the effect of headwinds on the proto-planets' atmospheres. We may also present first preliminary results on the atmospheric properties of protoplanets on supersonic, eccentric orbits.

Primary author(s): KUIPER, Rolf (University of Tübingen)
Comments: Presentation is based on Ormel, Kuiper, & Shi (2015) Ormel, Shi, & Kuiper (2015) Cimerman, Kuiper, & Ormel (2017) Moldenhauer et al., in prep. Mai et al., in prep.

ALMA reveals a pseudo-disk in a proto-brown dwarf

Core collapse models of brown dwarf formation predict the presence of a flattened “pseudo-disk” structure with spatial extents of a few hundred AU. We present the first observational evidence of a pseudo-disk in a proto-brown dwarf that drives a HH jet. Our analysis is based on ALMA CO (2-1) line and 1.37 mm continuum observations at an angular resolution of 0.4 arcsec. The pseudo- disk is elongated in a direction perpendicular to the jet axis, with a total (gas+dust) mass of 0.02 Msun and a size of $\sim$150 AU. It shows a large velocity gradient of $\sim$2 km/s and a combination of infalling and rotational motions, indicating a contribution from a pseudo-disk and an unresolved inner Keplerian disk. A comparison of the H2 column density derived from the CO line and 1.37 mm continuum emission indicates that only about 1.7 of the CO is depleted from the gas phase. In addition, there is emission detected in the H2CO (3-2) and N2D+ (3-2) lines. H2CO emission likely probes the inner Keplerian disk where CO is expected to be frozen, while N2D+ possibly originates from an enhanced clump at the outer edge of the pseudo-disk. We have considered various models (core collapse, disk fragmentation, circum-binary disk) that can fit both the observed CO spectrum and the position-velocity offsets. The observed morphology, velocity structure, and the physical dimensions of the pseudo-disk are consistent with the predictions from the core collapse simulations for brown dwarf formation. From the best model fit, we can constrain the age of the proto-brown dwarf system to be $\sim$30,000-40,000 yr. The proto-brown dwarf is in transition from Class 0 to Class I, consistent with the finding of a pseudo-disk structure, intermediate between an infalling envelope and a Keplerian disk.

Primary author(s): RIAZ, Basmah (Ludwig-Maximilians-Universität München); MACHIDA, Masahiro (Kyushu University); STAMATELLOS, Dimitris (UCLAN, UK)

Can dust back-reaction stop the accretion of gas at the water snowline?

In protoplanetary disks the gas accretion is driven by its viscous turbulence, while the dust grains couple to the gas motion depending on their size. However, in regions with a high concentration of solids, such as the water snowline, the dust particles can also perturb the gas dynamics. Using numerical simulations, we show that the dust back-reaction can stop the gas flux at the snowline location, and further enhance dust-to-gas ratio in the inner disk. Yet, we also find that the back-reaction is only efficient in disks with a low turbulence, a high primordial dust-to-gas ratios, and that the effects stop once the reservoir of solid material from the outer disk is exhausted.

Primary author(s): GÁRATE, Matías (Ludwig-Maximilians-Universität München)
Co-author(s): BIRNSTIEL, Til (Ludwig-Maximilians-Universität München); DRAZKOWSKA, Joanna (Ludwig-Maximilians-Universität München); STAMMLER, Sebastian Markus (Ludwig-Maximilians-Universität)

OGLE-ing the Variable Sky

Room 9.22
Content: The Optical Gravitational Lensing Experiment (OGLE) is a long-term large-scale variability survey conducted at Las Campanas Observatory, Chile. The Principal Investigator of the project is Prof. Andrzej Udalski, the 2018 Karl-Schwarzschild Medal winner. OGLE started in 1992, with a monitoring programme of 2 million stars towards the Galactic bulge. The prime goal of the programme was the detection of microlensing events and characterization of dark massive halo objects, suspected components of the mysterious dark matter. Currently, OGLE monitors over 2 billion stars of the Milky Way stripe and Magellanic Clouds in searches for any kind of variable objects: periodic, irregular as well as transients. The survey has a significant impact on modern stellar astrophysics and other fields of astronomy. In 2002, OGLE opened the era of extrasolar planets detection through the transit technique. Out of some 2000 microlensing events recorded every year, several events are of unique planetary nature. OGLE has discovered a full variety of exoplanets: Jupiter-like, ice giants, cold super-Earths, and many candidates for free-floating planets.

Among hundreds of extragalactic transients observed in the background of the Magellanic System, OGLE has found rare types of supernovae and candidates for tidal disruption events. Thanks to regular high-cadance observations, OGLE has discovered and classified, so far, over one million genuine variable stars, including precious pulsating stars, such as Cepheids and RR Lyrae-type stars. These stars are used to trace the structure of young and old populations in the Milky Way and nearby satellite galaxies. Very recently, an unexpected, completely new class of variable stars has been found in the OGLE data, the Blue Large-Amplitude Pulsators. OGLE has provided a proof that rare spectacular phenomena called red novae are stellar mergers. Long-term observations of millions of sources allow studying various processes happening on long time-scales, such as photometric behaviour of quasars and evolutionary changes in stars and stellar systems. During the meeting various OGLE-related topics as well as the OGLE data archive will be presented.

Past and Future of Microlensing

Microlensing's past success was founded on dedicated wide-field surveys that both directly yielded ground-breaking science, and leveraged access to powerful general-use instruments, ranging from 0.3m amateur networks to 10m AO to 100m VLTI interferometer, to satellites including HST, Spitzer, Kepler, and Gaia. Microlensing's future must be guided by the same approach, with a focus on mass and distance measurements of black objects that cannot be detected in any other way, i.e., black holes (BHs) and "black planets" (BPs). The former include isolated BHs and BH binaries in the AU range. The latter include free-floating planets and low-mass planets with decade+ periods. This will require the combination of ground-surveys that are at least as powerful as today's with a set of 2–6 small dedicated microlens parallax satellites. On this basis, microlensing can gain access to next-gen path-breaking instruments, including 30m AO, IR-Gaia-II, and next-gen interferometers to pursue a wide range of science goals.

Primary author(s): GOULD, Andrew (Ohio State University)

Microlensing exoplanets

Microlensing detection of exoplanets has unique capability of discovering planets on wide or very wide orbits around stars less massive than Sun. Among dozens of microlensing planets detected so far, we see objects of particular interest like very wide orbit planets or planets in binary stellar systems. The microlensing discoveries of super-Jupiter planets orbiting low mass stars beyond the snow line ($\sim 2.7\,\mathrm{AU}$) challanges the core-accretion model of planet formation. Microlensing also allows statistical studies and one of the findings is a break in planet-to-star mass ratio function at $\sim 10^{-4}$. The OGLE project has led discoveries of the first microlensing planets and has significant contributions to most of the other detections. I will discuss main results of microlensing planet searches.

Primary author(s): POLESKI, Radoslaw (Ohio State University)

OGLE data products

I will briefly present the OGLE website and on-line data archive.

Primary author(s): PIETRUKOWICZ, Pawel (Warsaw University Observatory)

RR Lyrae stars to trace the early formation and evolution of the Galactic spheroid

We plan to discuss the evolutionary and pulsation properties of RR Lyrae stars and their role as primary distance indicators and tracers of the old ($t > 10$ Gyr) stellar component.We also plan to trace the transition between the Bulge and the Halo by using the RR Lyrae pulsation properties provided by long term photometric surveys (OGLE, Gaia, Catalina). In particular, we will focus our attention on a new method based on optical and near infrared mean magnitudes to constrain the individual distance, reddening and metal content of RR Lyrae stars. Moreover, we will discuss the metallicity distribution of field RR Lyrae based on low-resolution spectra either collected by SDSS-SEGUE or available in the literature. The shape and the standard deviation of the metallicity distribution are fundamental diagnostics to constrain the fraction of stellar populations either formed in situ or accreated by our galaxy. Finally, we will outline the role that high-resolution optical and near infrared spectroscopy of field and cluster RR Lyrae is going to play to further constrain the chemical enrichment history of old stellar populations.

Primary author(s): BONO, Giuseppe (University of Rome Tor Vergata)

The EREBOS project: Studying the influence of low-mass companions on late stellar evolution

Post-common envelope binaries are highly important for resolving the poorly understood, very short-lived common envelope phase of stellar evolution. Hence, the observation of such systems over the whole parameter space will help to improve the comprehension of this phase, which is essential to understanding binary evolution. Hot subdwarfs (sdO/Bs) are the bare helium-burning cores of red giants which have lost almost all of their hydrogen envelopes. This mass loss is often triggered by common envelope interactions with close stellar companions. However, several close brown dwarf companions have been found, and interactions with even less massive objects like hot Jupiter planets have been proposed as a possible formation channel for the known single sdO/B stars. The on-going EREBOS project is dedicated to increase the number of analysed sdB binaries with cool companions. In optical surveys as OGLE or ATLAS more than 170 new eclipsing systems have been found. They allow the accurate determination of the fundamental orbital and stellar parameters of each system. In this talk, I will introduce the EREBOS project with special emphasis on our target selection from different optical surveys and give some first results.

Primary author(s): SCHAFFENROTH, Veronika (Insitut für Physik und Astronomie, Universität Potsdam)

OGLE view on pulsating stars

Thanks to regular monitoring of tens of thousands of pulsating stars in several stellar systems, OGLE project has changed our view on this important class of variable stars. Long and top quality photometry allowed for discovery of new classes of pulsating stars and new dynamical behaviours in the already known groups. Additional milimagnitude periodicities, beyond radial modes, have been discovered in both classical Cepheids and in RR Lyrae stars. These exciting new discoveries challenge our understanding of the pulsation dynamics in large-amplitude pulsators.

Primary author(s): SMOLEC, Radoslaw (Nicolaus Copernicus Astronomical Center)

The Milky Way Bulge/Bar

The Milky Way bulge is of box/peanut shape and comprises the inner parts of the Galactic bar. This talk gives a historical perspective of our understanding of the inner Galaxy, as well as a report on the rapid recent progress regarding the structure and dynamics of the bulge/bar, based on large stellar surveys.

Primary author(s): GERHARD, Ortwin (MPE)

Structure of the Magellanic System

A vast sky coverage of more than 700 square degrees in the area of the Magellanic System makes the OGLE database perfect for studying detailed properties of both the LMC and SMC as well as the Bridge. I will present results of a subproject entitled “OGLE-ing the Magellanic System”, devoted to studying the three-dimensional structure of the Magellanic System. We used 9000 classical Cepheids and 23000 RR Lyrae stars from the almost complete OGLE Collection of Variable Stars to study detailed structure of both Magellanic Clouds. In these galaxies Cepheids are clumped in substructures while RR Lyrae stars are more spread. We also analyzed distribution of classical pulsators stars in the Magellanic Bridge area. We show that young stars form a bridge-like connection between the Clouds, while old are more spread and resemble two extended overlapping structures.

Primary author(s): JACYSZYN-DOBRZENIECKA, Anna (Universität Heidelberg, Astronomisches Rechen-Institut)

Optical Variability of AGNs

I will briefly review basic analysis methods used to describe the typical optical variability of AGNs - structure functions and the damped random walk model - their applicability, usage, biases and caveats, and limitations. I will present some of the results for the SDSS Stripe82 and OGLE AGNs.

Primary author(s): KOZLOWSKI, Szymon (Warsaw University Observatory)

Solar Activity

Room 9.12
Content: Aim of the meeting is to study the magnetic activity of the Sun from the solar interior through the photosphere and atmosphere into the heliosphere. We aim to bring together experts in observation, theory and modelling and invite the submission of abstracts for talks and posters regarding the topics:

- Solar dynamo and helioseismology
- Measuring and modelling solar magnetic fields in the photosphere, chromosphere, corona and heliosphere
- Eruptive phenomena – flares, filaments, coronal mass ejections, jets
- Heating of the upper solar atmosphere
- Acceleration and evolution of the solar wind
- Solar Energetic Particles (SEPs)

Constraints on the Origin of Solar Active Regions

Flux emergence is the most obvious manifestation of the solar dynamo and an essential ingredient in current solar-like dynamo theories. However, it is not known whence the flux originates; from deep in the convection zone, or closer to the surface. Helioseismology has the potential to probe the subsurface flows and dynamics associated with activity. Via a statistical analysis of the line- of-sight magnetic field and surface flows of 188 emerging active regions observed by SDO/HMI, I will show that the flows associated with emergence are on the order of the convective velocities; the separation speed of the active region polarities occurs in two distinct phases; the east-west separation of the active region polarities is symmetric; and the tilt angle of the polarities sets in after flux has first appeared at the surface. These constraints suggest that near surface convection plays a strong role in active region formation.

Primary author(s): SCHUNKER, Hannah (MPS Göttingen)

Helioseismology of the Solar Dynamo

In this contribution, we report about our latest developments in helioseismology to probe for large- scale magnetic fields in the solar interior. We present theoretical calculations on the effect of magnetic fields on solar oscillations. Based on this we evaluate possible variable magnetic field models to obtain constraints on the location and strengths of the Sun's interior toroidal magnetic field during solar minimum and maximum.

Primary author(s): KIEFER, René (Leibniz-Institut für Sonnenphysik)

Photospheric magnetic fields: recent developments and future prospects

In this talk I will review a number of recent results that, in my opinion, have greatly changed the way we think about magnetic fields in the solar photosphere. Starting in the quiet Sun I will report a number of results, both from numerical simulations and observations, that hint at the existence of flux-sheet emergence. This form of flux emergence is rather different from the magnetic loop emergence and therefore it can significantly impact the way we look at this fundamental process of the solar photosphere. In the magnetism of the quiet Sun internetwork there has been great progress too. I will report on a very recent result that seems to have finally settled the long standing question of whether the magnetic fields in the internetwork are mostly contained on, or are perpendicular to, the solar surface. This work provides very robust and strong support for magnetic fields parallel to the solar surface at all photospheric heights and at all heliocentric angles. In the field of sunspot magnetic field it is worth mentioning the latest development of inversion codes for the radiative transfer that now allow to infer the physical parameters (temperature and magnetic field) as a function, not of the optical depth, but as a function of the vertical coordinate 'z'. These new codes also retrieve physical parameters like the gas pressure and density, that have been largely ignored in the past. Moreover these codes have the potential to retrieve trustworthy electric currents in the solar photosphere, thereby greatly improving our space-weather forecast capabilities.

Primary author(s): BORRERO, Juan Manuel (Leibniz Institut für Sonnenphysik)

Recent progress in solar chromospheric and coronal physics

The Sun's outer atmosphere surrounding the cooler photosphere is magnetically dominated. The intricate interactions between the magnetic field and plasma lead to a variety of structures in the solar chromosphere and corona. These structures and the associated dynamics span over a wide range of spatial and temporal scales, and they transform the solar atmosphere into a perfect laboratory to observe and study the properties of magnetised plasmas. Advances in observing and numerical techniques over the last decade have significantly improved our knowledge of the solar atmosphere. For instance, now there is a better understanding of the origin of widely occurring, small-scale ($\sim$100-1000 km) plasma jets and bursts in the solar atmosphere. However, we still lack a complete picture of the magnetic coupling through the solar atmosphere. In this talk, I will review recent progress in the physics of solar atmosphere and discuss some open questions that will be addressed with upcoming telescopes and future models.

Primary author(s): CHITTA, Lakshmi Pradeep (MPS)

Test magnetohydrostatic extrapolations with a radiative MHD simulation of a flare

A nonlinear magnetohydrostatic (NLMHS) model is a better approximation of the physical state in the lower solar atmosphere than a nonlinear force-free field (NLFFF) model. The latter one is only valid in the low plasma-beta corona. The magnetohydrostatic model computes self-consistently the magnetic field and plasma distribution. We tested the new code with exact equilibria (Zhu & Wiegelmann, 2018, ApJ, 866, 130) and found the NLMHS code has been able to meaningfully recover the plasma density, pressure and magnetic field. Here we present a more challenging test of our model with a radiative MHD simulation of a solar flare. The simulation spanning from the upper convection zone into the solar corona. Many physical processes (3D radiative transfer, optically thin radiation, field aligned heat conduction, etc.) are considered in different parts of the sun, which make the simulation a pretty realistic one. Through extrapolating one snapshot of this simulation with its photospheric vector magnetogram, we derive the magnetic field that is more accurate than NLFFF. Besides, the NLMHS model can recover the main structure of plasma in the photosphere and lower chromosphere.

Primary author(s): ZHU, Xiaoshuai (MPS)
Co-author(s): WIEGELMANN, Thomas (MPS)

FitCoPI: fitting density and temperature of coronal active region plasma in 3D

Since the solar coronal plasma is optically thin, diagnostics of coronal plasma basically have no resolution along the line of sight. So far, this problem can be overcome only either by stereoscopic observations, or by observing the sun repetitively with enough time lag. The former approach has the problem that STEREO data is not generally available. The latter one suffers from poor time resolution, since the sun needs to rotate until the perspective changes significantly. We present our newly developed FitCoPI code. It implements a novel method of fitting the solar active region corona to single vantage point observations. The method requires a set of simultaneous EUV or X-ray images. The outcome is an 3D approximation of the density and temperature in the corona. The method is tested against a model corona. Using SDO/AIA data, it is further applied to AR 11087, observed on July 15th 2010, for which the results can be tested against independent data from STEREO A/EUVI. In both cases, the results are very satisfying, though some problems remain near the solar surface.

Primary author(s): BARRA, Stephan (MPS)

New Challenges in Stellar Spectroscopy - Part 1

Room 47.06

Content: Accurate determination of the parameters of stars is of fundamental importance for many fields of astrophysics such as exoplanets, Galactic structure, and cosmology. The quantitative analysis of stellar spectra has a long history in Germany. Especially in the last decade, a significant progress has been made thanks to advanced theoretical model atmospheres for cool and hot stars, the availability of excellent spectroscopic data from X-ray to infrared, improved atomic and molecular data, and the increase in computing power.

Large spectroscopic, astrometric and photometric stellar surveys such as 4MOST, Gaia or LSST, are revolutionising the field. However, these crucial developments in observational astronomy pose major challenges for the application of the sophisticated theoretical methods to the data. Processing and analysing millions of stellar spectra calls for automated approaches with large model grids and systematic uncertainties due to unavoidable simplifications need to be properly assessed. Besides, these large-scale stellar surveys expose a new kind of challenge — the enormous diversity of stellar objects in the Milky Way and beyond. Peculiar and interesting objects discovered in the new wealth of data, such as very metal-poor stars, red supergiants, or compact remnants of failed thermonuclear supernovae, require tailor-made models and individual analyses.

In connection to that several problems need to be addressed: How can accurate distances and multi-band photometry be combined with spectroscopic analyses in a most efficient way? What are the synergies between spectroscopy and the emerging field of asteroseismology? How do new stellar structure models compare with parameters derived by combining model atmospheres and observations? And finally, how can we best exchange and publish our data, models and codes to make them available for the next generation of researchers in the field?

In this splinter session we aim at gathering the stellar community to present most recent results both in observation and theory. While the focus will be on stellar spectroscopy, alternative methods of quantitative analyses of stars will be discussed as well.

New challenges in the spectroscopic analysis of cool stars

Review talk about the spectroscopic analysis of cool stars.

Primary author(s): BERGEMANN, M. (MPIA)

New challenges in the spectroscopic analysis of hot stars

Review talk about the spectroscopic analysis of hot stars.

Primary author(s): IRRGANG, A. (Universität Erlangen-Nürnberg)

The chemical compositon of heavy-metal hot subdwarfs: HZ44 and HD127493

Hot subdwarf stars of spectral type O and B (sdO and sdB) represent late stages of the evolution of low-mass stars. They are characterized by high effective temperatures, ranging from Teff = 20 000 K to more than 45 000 K while their surface gravities are typically between logg = 5.0 and 6.5. While sdOs are predominantly hydrogen deficient, most sdBs are helium deficient. Whether the small group of intermediate helium-rich (iHe) sdO/B stars provides an evolutionary link between the dominant classes is an open question. Some of these iHe sdO/Bs show extreme enhancement in heavy metals, but until recently only three stars of that type were known. The presence of strong Ge, Sn, and Pb lines in the UV spectrum of the iHe-sdO HZ44 suggests a strong enrichment of heavy elements, calling for a detailed analysis of its composition. We combine non-LTE model atmospheres with high-quality optical and (F)UV spectra of HZ44 and its hotter sibling HD127493 to determine their atmospheric parameters and metal abundance patterns. By collecting atomic data from literature we succeeded to determine abundances of 29 metals in HZ44, including the trans-iron elements Ga, Ge, As, Se, Zr, Sn, and Pb. This makes it the best described hot subdwarf in terms of chemical composition. We also determined the abundance of 15 metals in HD127493, including Ga, Ge, and Pb. Heavy elements turn out to be overabundant by one to four orders of magnitude with respect to the Sun, with Zr and Pb among the most enriched elements. The resulting abundance patterns are discussed in the context of nucleosynthesis and diffusion processes.

Primary author(s): DORSCH, Matti (Universität Potsdam)

High-quality spectral analysis of hot, compact stars

Stellar atmospheres are prime laboratories to determine atomic properties of highly ionized species.
A detailed investigation on the precision of many iron-group oscillator strengths is still outstanding. With the Space Telescope Imaging Spectrograph, we obtained high-resolution spectra of three hot subdwarfs, namely EC 11841-2303, Feige 110 and PG 0909+276, that exhibit very high iron-group abundances. The predicted relative strength of the identified lines are compared with the observations to judge the quality of Kurucz's line data and to determine correction factors for abundance determinations of the respective elements. I present first results of this project.

Primary author(s): LANDSTORFER, Alexander (University of Tübingen)

Run-away and Hyper-velocity stars in the Gaia era: Old friends and new guys

Run-away stars are objects ejected into the halo from their place of birth. The most extreme ones, the hyper-velocity stars (HVSs), travel, so fast that they can overcome the gravitational pull of the Galaxy. The first HVSs were discovered serendipitously in 2005 and tidal disruption of a binary by the super-massive black hole (SMBH) in the Galactic centre was readily accepted as acceleration mechanism. The unprecedented precision of Gaia proper motions now brings us in a position to constrain the place of origin of known HVSs as well as search for new ones.
The first Gaia results immediately showed that the phenomon is much more diverse and the SMBH slingshot mechanism can not be the only one, in particular for low-mass, evolved HVSs. Instead, binary supernova scenarios involving thermonuclear explosions of white dwarfs are promising to explain ejected donor stars as well as the newly discovered partly burnt remnants of the exploding white dwarf, so-called "Zombie" stars.

Chemical tagging is an important tool to identify the ejection mechanisms. This, however, is a challenge to stellar atmosphere modelling, because high precision is required to detect the faint imprints of supernova debris. Even more challenging is the modelling of partially burnt white dwarf remnants, because their spectra are very peculiar, devoid of H, He and C, but dominated by strongly enhanced heavier metals, such as Ne, Mg, and the iron group elements.

Primary author(s): HEBER, U. (Universität Erlangen-Nürnberg)

Star Formation and Stellar Feedback

Room 47.05

Content: Massive stars play a key role in the evolution of the interstellar medium (ISM) in galaxies. They ”stir” the ISM through various processes such as ionization, stellar winds, radiation pressure, and finally supernova explosions. This mechanical and radiative feedback of massive stars on their environment regulates the physical conditions of the ISM, sets its emission characteristics, and ultimately governs the star formation activity through negative (molecular cloud destruction) and positive (cloud compression) feedback. Understanding the physical processes that regulate the impact of massive stars on their environment is thus a key question in modern astrophysics.

Significant observational progress has been achieved during the last decade in particular by submm/(far)-infrared facilities such as Spitzer, Herschel, ALMA, IRAM, SOFIA, and many others. For example, accretion and ejection processes involved in protostellar evolution have been investigated, the ubiquity of Galactic and extragalactic HII-region bubbles was revealed, and spectroscopy of mm- to FIR-lines of CO, of (ionized) carbon, and (neutral) oxygen, helped to better understand the gas cooling of the ISM. In parallel, increasingly more complex simulations and theoretical studies allowed us to advance our understanding of molecular cloud formation and star formation.

We here propose a splinter meeting with the aim of summarizing our current observational and theoretical understanding of feedback effects in the ISM. Individual aspects and current topical projects will be highlighted by presentations of experts in the field. The objective is to stimulate discussions within the community of observers and modelers.

Some key questions that will be addressed are:

- How can we translate our observations into diagnostics of ISM parameters such gas density, gas temperature, strength of UV-field, etc. and what is the best way to compare with simulations?

- Which improvements are needed for PDR- and shock-modelling (time dependence, dynamics,..) to better explain the observations?

- Which are the dominant feedback processes, including shocks, in various regions? - What about diagnostics for triggered star formation, cluster formation?
- What about evidence for protocluster collapse? protostellar accretion bursts?

Introduction to star formation and stellar feedback

I will present some introductory remarks to the 2019 AG splinter meeting on “star formation and stellar feedback”, outlining the various feedback mechanisms in what John Bally calls the “star formation feedback ladder”. There is positive and negative feedback, promoting and hindering star formation, i.e. cloud compression and cloud destruction, respectively. Negative feedback includes radiative processes such as photoionisation/photodissociation (HII regions/PDRs), mechanical energy input (jets and outflows, young star explosions, stellar winds, supernovae). Positive feedback can include shocks, triggered star formation, and cosmic ray ionisation (its role for ion-neutral magnetic coupling and astrochemistry). There is a recent Cycle 7 SOFIA Legacy programme “Feedback” (led by Nicola Schneider and Xander Tielens) to investigate heating and cooling in several galactic star forming regions, including simulations of the far-infared observations. I will only have time to briefly discuss what can be expected in the near future,from these as well as other SOFIA spectroscopic observations (e.g. infall). My goal is to stimulate interest and excitement among the participants and beyond. Some 10,000 papers about star formation and stellar feedback have been published since 1992, which goes to show the major importance of stellar feedback for star formation (massive stars, star clusters vs. associations) and galaxy evolution, particularly at high redshift.

Primary author(s): ZINNECKER, Hans (Universidad Autonoma de Chile/University of Stuttgart)

SOFIA observations of [OI]-outflows from class I objects

Highly collimated jets driven by newly born protostars are an integral part of star formation. To properly understand the role of jets in the dynamics and evolution of the accreting system, we need to know basic physical parameters that are connected to their formation mechanism. Here we present FIFI-LS spectroscopic [OI] 63μm,145μm maps of five prototypical class I outflows (HH111, SVS13, HH34, HH26, HH30), that enable us to study the extent of warm low excitation atomic gas in these flows, e.g. measure the mass flux rate in the atomic jet and the accretion/ejection ratio of matter.

Primary author(s): SPERLING, Thomas (Thüringer Landessternwarte); EISLÖFFEL, Jochen (Thüringer Landessternwarte); FISCHER, Christian (Deutsches SOFIA Institut, University of Stuttgart); NISINI, Brunella (INAF-Osservatorio Astronomico di Roma); GIANNINI, Teresa (INAF-Osservatorio Astronomica di Roma); KRABBE, Alfred (Deutsches SOFIA Institut, University of Stuttgart)

First Hydrodynamics Simulations of Radiation Forces and Photoionization Feedback in Massive Star Formation

We present the first simulations of the formation of massive stars which account for radiation forces as well as photoionization feedback simultaneously. We perform direct hydrodynamics simulations of the gravitational collapse of high-density mass reservoirs toward the formation of massive stars including self-gravity, stellar evolution, protostellar outflows, continuum radiation transport, photoionization, and the potential impact of ram pressure from large-scale gravitational infall. For direct comparison, we execute these simulations with and without the individual feedback components. Furthermore, each simulation series is performed starting from two different accretion scenarios, namely a finite small-scale mass reservoir such as a pre-stellar core vs. a virtually infinite reservoir which accounts for large-scale accretion flows. Eventually, we derive the size of the reservoir from which the forming stars gained their masses. Photoionization and HII regions dominate the feedback ladder only at later times, after the star has already contracted down to the zero-age main sequence, and only on large scales. Specifically, photoionization yields a broadening of the bipolar outflow cavities and a reduction of the gravitational infall momentum by about 50%, but does not limit the stellar mass accretion. On the other hand, we find radiation forces restrain the gravitational infall toward the circumstellar disk, impact the gravito-centrifugal equilibrium at the outer edge of the disk, and eventually shut down stellar accretion completely. The most massive star formed in the simulations accreted 95 Msol before disk destruction; this mass was drawn-in from an accretion reservoir of approximately 240 Msol and 0.24 pc in radius. Concluding, in the regime of very massive stars, the final mass of these stars is controlled by their own radiation force feedback. As preliminary work, I will show our results of scanning the metallicity dependence of these radiative feedback components from the cosmic dawn to the present-day universe.

Primary author(s): KUIPER, Rolf (Universität Tübingen)
Comments: Presentation is based on Kuiper & Hosokawa (2018), A&A 616

The Expanding Orion Nebula

We have studied the large-scale dynamics of the Orion molecular cloud using SOFIA/upGREAT velocity-resolved observations of the fine-structure line of ionized carbon ([CII]). We find that [CII] observations are a unique tool to detect and analyze bubbles in the ISM blown by stellar winds or driven by thermal expansion of the ionized gas. Especially the Orion Veil is revealed to expand at 13 km/s due to the stellar wind of the central star, θ 1 Ori C, thus effectively sweeping up and removing material from the OMC1 star forming core.

Primary author(s): PABST, Cornelia

UV-Line-Driven Disk Ablation as a Unified Explanation for the Lifetime of Oe/Be Star Disks and the Upper Mass Limit of Stars in the Present-Day Universe

The extreme luminosities of massive, hot OB stars drive strong stellar winds through line-scattering of the star's UV continuum radiation. For OB stars orbited by a circumstellar disk, we explore the effect of line-scattering in driving an ablation of material from the disk's surface layers. For this we apply a multidimensional radiation-hydrodynamics code that uses a multi-ray Sobolev treatment of the line transfer. This fully accounts for the efficient driving along non-radial rays due to desaturation of line-absorption by velocity gradients associated with the Keplerian shear in the disk as well as the effect of multiple line resonances off the stellar limb. Furthermore, we account for the continuum optical depth of the disk along all rays by introducing a semi-analytical approximation. In the case of evolved classical Oe/Be stars, our results show a dense, intermediate-speed surface ablation, consistent with the strong, blue-shifted absorption of UV wind lines seen in Be shell stars that are observed from near the disk plane. For optically thin Be disks, this leads to a disk destruction time of order months to years, consistent with observationally inferred disk decay times. Around O stars this time reduces to order days, making it more difficult to sustain a disk in earlier spectral types, and so providing a natural explanation for the relative rarity of Oe stars in the Galaxy. In the case of forming massive stars, we find that ablation rates depend strongly on stellar parameters, but that this dependence can be conveniently parameterized as a nearly constant, fixed enhancement over the classical stellar wind mass loss rate, allowing us to predict the rate of disk ablation for massive stars as a function of stellar mass and metallicity. By comparing this to predicted accretion rates, we derive an upper mass limit for massive stars forming by disk accretion.

Primary author(s): KUIPER, Rolf (Universität Tübingen)
Comments: This presentation is based on the following articles: Kee, Owocki, & Kuiper 2018a Kee, Owocki, & Kuiper 2018b Kee & Kuiper 2018

GREAT explorations in the bright photodissociation region of the Lagoon Nebula

The Lagoon Nebula, M8, is one of the most prominent star-forming regions in the section of the Sagittarius-Carina Arm lying near our line of sight toward the Galactic center. The bright stellar system of M8, Herschel 36 (Her 36), is responsible for ionizing the HII region of NGC 6523 and heating the photodissociation region (PDR). Using SOFIA, APEX and IRAM-30 m telescopes, we carried out a comprehensive survey to explore the morphology of M8 and to quantify the physical conditions of the gas responsible for the emission of various molecules. Comparing the archival infrared, optical, and radio images of the nebula with our obtained CII and CO data, we found that M8 has a face-on geometry with the cold dense molecular cloud behind Her 36 and a warm PDR veil surrounding it, which is accelerated toward the observer. We obtain H 2 densities ranging from $\sim 10^4 - 10^6\,\mathrm{cm}^-3$ and kinetic temperatures of 100-150 K in the bright PDR caused by Her 36 using radiative transfer modeling of various transitions of CO isotopologs (Tiwari et al. 2018 & Tiwari et al. 2019). Also, using our recent observations with the upGREAT receiver onboard SOFIA, we investigate the role of OI in probing the density gradients in the PDR of M8. Furthermore, we study the carbon chemistry using the new CH observations with SOFIA (Tiwari et al. in prep).

Primary author(s): TIWARI, Maitraiyee

Multiplicity of high-mass star formation due to disk fragmentation

We performed radiation-hydrodynamical simulations on disk fragmentation around forming massive stars, starting with the collapse of a $200 M_\odot$ molecular cloud, and focusing on the first 20 000 yr of evolution, where a fragmenting accretion disk is formed. These simulations were performed on a spherical grid and logarithmically increasing radial coordinate with the code Pluto, with the addition of custom modules for radiation transport and self-gravity. For the first time, the physics of the fragmentation process are resolved without the need for a sink particle subgrid model for the fragments. We identified a distinct epoch where fragmentation occurs. We followed the mass, temperature and orbit of the fragments, and studied the possibility of their further development as low-mass companions, as well as the interactions between the fragments and their interaction with the disk. From this analysis, we identify $\sim$4 fragments that will probably become low-mass companions.

Primary author(s): OLIVA-MERCADO, G. André (Universität Tübingen); KUIPER, Rolf (Universität Tübingen)

Resolving supernova-feedback in simulations of galaxy formation

We investigate the physical properties of 75 simulations of isolated supernova-feedback events to determine the resolution requirements for resolving the Sedov-Taylor phase of a supernova-remnant in simulations of galaxy formation and evolution. The simulations are carried out with the code P-Gadget3 using a modified solver for the equations of hydrodynamics, the meshless finite mass method (MFM, Hopkins 2015). We investigate the most important physical properties (e.g. sizes, momentum input, energy distribution, mass distribution and pressure) of each remnant at four resolution levels from 0.1 $M_{\odot}$ to 100 $\mathrm{M}_{\odot}$ and in six different environmental densities from 0.001 cm^{-3} to 100 cm^{-3}. The two most important quantities that have to be resolved within the Sedov-Taylor phase are the shell momentum and the pressure within the hot bubble. Those two quantities can be resolved in all regimes with a mass resolution of 10 $M_{\odot}$. While the momentum generates observed velocity dispersions of around 10 km s^{-1} and subsequently is the origin of interstellar turbulence, the hot phase of each remnant provides for the pressure within the inter stellar medium (ISM) which can lead to galactic outflows driven by the formation of superbubbles that leave the galactic midplane. Unlike other studies of the same kind (e.g. Kim & Ostriker 2015) we carried out all the simulations at three different target metallicities and with the effect of isotropic thermal heat conduction. While we find that only a weak dependence on the metallicity thermal conduction leads to more hot mass and slightly faster cooling. However, we note that we focus on low metallicity regimes where stellar winds are assumed to be subdominant (e.g. high redshift, dwarf galaxies). Moreover, all the simulations utilize a non-equilibrium network for cooling and chemistry (Glover and McLow 2007). Therefore, we can follow the chemical evolution of each remnant in great detail.

Primary author(s): STEINWANDEL, Ulrich (MPA); MOSTER, Benjamin (MPA); NAAB, Thorsten (MPA); HU, Chia-Yu (Flatiron Institute/CCA); WALCH, Stefanie (University of Cologne)

Comments: This work is the first part of a study which is investigating SN-feedback in low metallcitiy environents. There will be a related talk from my Supervisor Dr. Benjamin Moster on the impact of SN-feedback on the multiphase ISM (e.g. turbulence, hot phase generation).

Connecting Observation and Theory - Contribution and Possibilities of laboratory Studies

Water is the major component of interstellar ice present in dense molecular clouds. The minor components, although, play an important role in influencing the chemical and physical properties of the ice. Molecular oxygen, for example, has been recently detected in a significant amount in Solar System comets and it is believed to influence the chemistry and energy balance of interstellar clouds. Although invisible in the IR spectroscopic range, the interaction of O_2 with the H_2O matrix environment perturbs the symmetry of the molecule which becomes visible in the mid-IR. Also, we can directly measure optical constants of molecules using a THz time domain spectrometer and derive dust opacities in the millimeter and sub-millimeter part of the electromagnetic spectrum. At these wavelengths ALMA and NOEMA can observe the dust continuum emission with very high angular resolution and sensitivity. Knowing the dust opacity thus allows us to model the dust continuum emission. Doing so, we want to answer the question: how do dust opacities change in thick icy mantles compared to those available in the literature? We present a spectroscopic characterization of water-oxygen mixtures in various molecular ratios, to support the astronomical observations. In addition to a two component O_2 -H_2O mixture, we investigate the effect of present CO and CO_2 on the O_2 band strength. Additionally, we present direct measurements of optical properties for astrophysical ice analogues using coherent THz radiation. Measurements for CO will be complemented by measurements for H_2O, CO_2 and N_2 .

Primary author(s): MUELLER, Birgitta (MPE); GIULIANO, Barbara Michela (MPE)
Co-author(s): VASYUNIN, Anton (Ural Federal University, Ekaterinburg, Russia); BIZZOCCHI, Luca (MPE); GAVDUSH, Arsenii (Prokhorov General Physics Institute of the Russian Academy of Sciences); IVLEV, Alexei (MPE); CASELLI, Paola (MPE)

The impact of supernova feedback on the multi-phase structure of the ISM

We investigate the behaviour of supernova feedback and its impact on shaping the ISM in simulations of galaxy formation and evolution. For this, we simulate a set of ISM patches (256 pc3) employing different column densities and supernova rates that are constrained from the Kennicutt relation. All simulations are carried out with a model for non-equilibrium cooling and chemistry both with and without self-gravity. The cooling and heating processes include fine structure line cooling of atoms and ions, Lyman-α cooling, rotational and vibrational lines of molecules, as well as photo-electric heating, cosmic ray ionisation, and pumping from UV-background. The chemical model follows the formation of molecular hydrogen, ionised hydrogen and carbon monoxide by integrating the non-equilibrium rate equations directly. The simulations are run at different mass resolutions (down to 0.1 solar masses) with the meshless finite mass (MFM) solver. We find a three-phase ISM consisting out of a hot, a warm and a cold phase. While the hot phase is taking most of the volume, most of the mass is contained in the cold neutral phase. In the runs without self-gravity we only form up to two per cent of molecular hydrogen for a setup comparable to that of the Milky Way. However, the runs with self-gravity result in molecular fractions of around twenty per cent which are in good agreement with observed molecular fractions of the Milky Way.

Primary author(s): MOSTER, Benjamin (Ludwig-Maximilians-Universität München); STEINWANDEL, Ulrich (MPA); NAAB, Thorsten (MPA)

The PDR in M17-SW analyzed with FIFI-LS onboard SOFIA

Photo-dissociation regions (PDRs) are the places where the radiative feedback by massive stars on molecular clouds happens. The molecular gas is photo-dissociated and then ionized by UV radiation. The UV radiation below 13.6 eV heats the gas via the photo-electric effect on dust grains. Cooling happens through the dust continuum and a handful of far infrared (FIR) fine-structure lines. FIFI-LS, the FIR spectrometer onboard the US-German airborne observatory, SOFIA, can map these main cooling processes efficiently. We observed the well-studied edge-on PDR, M17-SW, with high spatial resolution in all major FIR cooling lines of the ionized and neutral medium. By comparing the observed line intensities to model predictions we mapped the physical conditions of the ionized and neutral layer of the PDR by The [OIII] line ratio readily provides the electron density maps in the ionized layer just above the PDR. The analysis of the [OI], [CII], CO and continuum emission with the PDR Tool box allowed us to map the gas density and UV radiation field strength over the region. We also estimated the optical depth effects to the [OIII]63μm line and the contribution of the PDR to the ubiquitous [CII] emission for each map position. While the applied model is comparatively simple, a consistent picture of the spatial variation of the physical parameters over the mapped region could be derived. Based on these findings the processes and energetics in the PDR can be studied further possibly by applying more detailed models together with more data from other wavelengths.

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Studying light hydrides in the ISM using SOFIA

Despite being a commonly observed feature, the modification of velocity structure in spectral line profiles by hyperfine structure complicates the interpretation of spectroscopic data. In particular, this is true for observations of simple molecules such as CH and OH toward the Inner Galaxy which show a great deal of velocity crowding. In this talk I wish to address the influence of hyperfine splitting on complex spectral lines, from first principles through deconvolution and in particular by using the Wiener filter. Applying this technique to high spectral resolution observations of the rotational ground state transitions of CH near 2THz seen in absorption toward several strong FIR- continuum sources observed using GREAT on board SOFIA, we determine reliable column density estimates. Given, its status as a powerful tracer for molecular hydrogen in the diffuse regions of the ISM, we used it as a surrogate for H2 to determine the abundance of the OH molecule. We further emphasize the use of CH as tracer for H2 by comparing the radial distribution profile of CH and the corresponding derived H2 profile along the Galactic plane with that of [CII] 158 micron emission from the cold neutral medium, a well known CO-dark H2 gas tracer.

Primary author(s): JACOB, Arshia Maria (MPIfR)

Wednesday 18 September

The Early Milky Way as seen through Galactic Archeology - Part 1

Room 47.05
Content: There is no other galaxy that can be studied in as much detail as our own Milky Way. Only here can we study individual stars in great detail, both in their chemical abundance patterns and also in their kinematic and astrometric properties. By searching for distinct kinematic and chemical signatures, we can infer what the Galaxy was like at early times.

We are currently experiencing a revolution in the field of Galactic Archeology as a result of the Gaia mission as well as several large scale spectroscopic surveys (including multi-object spectrographs like WEAVE and 4MOST) that are either already ongoing or set to begin in the near future.

In this splinter session, we aim to bring together the German community working on various topics related to Galactic Archaeology (both theoretical and observational). Relevant topics include (but are not limited to):

- chemical abundance trends and kinematics of the bulge, disk and halo (observations and simulations)
- dwarf galaxies, stellar streams and substructure in the halo
- metal-poor stars
- (future) spectroscopic surveys and Gaia

Each of these individual topics (amongst others) are important to our understanding of the processes involved in formation and evolution of our Galaxy, but bringing them all together and placing them in context with each other is crucial in order to gain a big picture understanding of the (early) history of the Milky Way.

Asteroseismology of red giants and its applications to Galactic archaeology

Asteroseismology is the study of stellar oscillations with the aim of unravelling the interior structure of stars. With the advent of long-term high-precision space-based photometry (e.g. CoRoT, Kepler, Gaia, TESS) and high-resolution spectroscopy (e.g. SDSS) a golden era of stellar variability has begun. The quantity and quality of the data have reached a level to perform in-depth studies for hundreds of thousands of oscillating red-giant stars of various masses and chemical compositions throughout the Galaxy, for which we can reveal accurate stellar parameters including ages.

Primary author(s): THEMESSL, Nathalie (MPS)

Mapping the Milky Way with Gaia and large stellar surveys

Asteroseismic, astrometric, photometric, and spectroscopic surveys of stars provide the key to understanding the formation of our Milky Way. Large parts of the Galaxy still remain terra incognita, but major advances have been made in the last years. Gaia DR2 in particular has allowed for a major leap forward in mapping the Galactic disc, but it becomes even more powerful when combined with other surveys. In this talk I will discuss recent advances in the determination of precise stellar distances, stellar parameters, and interstellar extinction maps from multi-wavelength observations. I will also highlight the necessity of dedicated mock observations when comparing the data to state-of-the-art Milky Way models.

Primary author(s): ANDERS, Friedrich (ICCUB)

Clues to the secular origin of the Milky Way bulge from chemo-dynamics

Examining the chemo-dynamical relations of stellar populations in the Milky Way (MW) bulge can provide clues to the formation history of our Galaxy, and of disc galaxies in general. To explore the implications of a pure disc origin of the MW bulge I will show results from isolated N-body simulations of barred galaxies, where the bulge forms secularly through the vertical heating of a bar, which in turn forms from a composite thin+thick disc. As I will show, the chemo-dynamical properties of stellar populations in the MW bulge are well reproduced by a pure disc model, as is the metallicity distribution function (MDF) as a function of galactic longitude and latitude. Furthermore, I will show recent results from state-of-the-art cosmological simulations which hint at the in-situ origin of populations in the MW bulge. I will discuss these results in light of the mounting evidence - from morphology, kinematics and chemistry - of the MW bulge's pure (thin+thick) disc origin.

Primary author(s): FRAGKOUDI, Francesca (MPA)

Tracing the kinematics of metal-poor stars in the Galactic bulge with the Pristine Inner Galaxy Survey

The Milky Way bulge is generally thought to be made up mainly of former disc stars, in the form of a buckled bar. The contribution of a classical component is thought to be minimal. Observational support comes from the observed cylindrical rotation which has been seen in large samples of bulge stars. However, this is mainly based on metal-rich stars (which is the bulk of the stars in the bulge), at lower metallicity a pressure-supported component may be expected to play a larger role. The metal-poor tail of the bulge has not yet been studied in much detail, because numbers of metal- poor stars in bulge surveys are generally small. Surveys specifically targeted at low metallicities or very large surveys are needed to uncover significant samples of (very) metal-poor stars. The Pristine survey is such a metal-poor targeted survey, which uses a narrowband Ca H&K filter on CFHT MegaCam to very successfully uncover metal-poor stars photometrically. Here I will present recent results of the Pristine Inner Galaxy Survey (PIGS), which is building towards an unprecedented large sample of metal-poor stars in the bulge region. We use our low/intermediate resolution spectroscopic follow-up to study the kinematics of the metal-poor tail of the inner Galaxy and speculate about different scenarios that could create the observed trends.

Primary author(s): ARENTSEN, Anke (AIP)
Co-author(s): STARKENBURG, Else (AIP); MARTIN, Nicolas (University of Strasbourg); THE PRISTINE COLLABORATION

Building a global model for the secular evolution of the Galactic disk

We built and present a global model for the Milky Way's (low-alpha) stellar disk, to constrain its secular dynamical evolution through APOGEE and Gaia observations that provide [Fe/H], ages, radii and orbits from $\sim$ 3 kpc to $\sim$ 13kpc. The model presumes, and parametrizes, that the present disk structure arose through continuous start formation from a well-mixed ISM, ongoing chemical enrichment, inside-out growth and, importantly, radial migration. That continuous loss of dynamical formation memory, described as diffusion in orbit radii or angular momenta, is presumed to be driven by non-axisymmetries in the disk. We find that the p([Fe/H],age,R,L_z) data now available are very constraining. Yet, a good model can be found with plausible inside-out growth, sensible enrichment and extensive radial migration: over the age of the low-alpha disk (8 Gyr) the typical migration distance is about the disk half-mass radius. Consequently, the disk looks very regular without loosing its radial gradients. Modelling the secular evolution of the azimuthal and radial actions should now constrain the physical mechanisms of the secular orbit evolution.

Primary author(s): FRANKEL, Neige (MPIA)

Ensemble age inversions and galactic chemical evolution

We demonstrate that the direct use of age probability density function obtained from the isochrone fitting can lead to biased results. We present the method to derive underlying stellar age distribution from a stacked age probability density function for an arbitrary set of stars. The method allows to reconstruct a reliable age distribution for samples with at least 1000 stars.
As a demonstration of the method we apply it to public spectroscopic surveys: LAMOST, APOGEE and RAVE-on and demonstrate that the results are close to those derived from models and high-quality data for the Solar neighborhood.

Primary author(s): MINTS, Alexey (AIP); HEKKER, Saskia (MPS); MINCHEV Ivan

EScience and Virtual Observatory - Part 2

Room 9.11
Content: The importance of publicly available and accessible astronomical data sets for the feasibility and effectiveness of research in astronomy and astrophysics has been shown many times in the past years. From last year, perhaps the most spectacular example is the flood of results employing data release 2 of Gaia, facilitated at least in part by a well-designed, Virtual Observatory-based data dissemination and query infrastructure.

New instruments coming online in the next few years, from Euclid to SKA to LSST, will still require significant evolution as well as development of new methods to enable similar science success stories.

This is not merely a question of publication techniques. It also involves application machine learning, computational statistics or neural networks. Software development for astronomical machinery, for instrument data pipelines, and analysis of data still call for new approaches.

Providing suitable tools and research environments aiding scientists in essentially all fields of astronomy is a central part of astronomical research infrastructure. It will certainly only become more important, as will data management, data access, and data publication. This was recognised by the GWK initiating the NFDI (Nationale Forschungsdaten-Infrastruktur) program. Sharing the lessons learnt in astronomy and exploiting the promises of cross-disciplinary technology development using this platform will therefore be on the agenda for next years.

We invite you to share your experiences and ideas, learn from successful applications, and discuss problems, obstacles and challenges of publishing and exploiting both large and diverse data in our science.
We specially call for contributions to a session: “Demonstrate your favorite software / tool for doing astronomy!”

From Protoplanetary Disks to Exoplanets - Part 2

Room 9.41
Content: The formation of stars and their planetary systems are among the key questions in science. Only by addressing these fundamental questions, we can hope to unravel whether solar systems like ours are common and how many Earth-like planets our Galaxy may harbor. In recent years substantial progress in this direction has been achieved thanks to a powerful combination of high-resolution, high-sensitivity observations aided by detailed theoretical modeling and laboratory studies. The composition and properties of exoplanetary atmospheres are now becoming routinely accessible thanks to the high-resolution coronographic or spectroscopic observations from the ground and space. The diversity of observed exoplanets and their atmospheric composition suggests a tight link between exoplanets and the properties of their pre-natal environments, protoplanetary disks. From the optical to the (sub-)millimeter, observations provide strong evidence for the ongoing planet formation and the presence of planets in their pre-natal environments, protoplanetary disks.

The goal of the AG 2019 splinter meeting entitled "From protoplanetary disks to exoplanets - the story of their formation" is to bring together the German astrophysical community studying exoplanets, planet formation, and protoplanetary disks. Beside summarizing the status of the field in several lectures and presenting the latest, most interesting results, the organizers hope to stir the discussions and exchange of ideas within our diverse research field. Key scientific topics include (but are not limited to):

- What are the physics and chemistry of planet-forming disks? How do these disks evolve?
- What are the conditions under which planets form?
- Which processes shape the properties of planets and their atmospheric compositions?
- Is our solar system unique or common?
- Which processes do we have to test (and exclude) in order to identify the imprints of planets on disks?
- Might other processes (such as magnetic fields) solve the chicken-and-egg problem of planet formation?

Planet migration in protoplanetary disks

Already after the discovery of the first exoplanet, 51 Peg, it became clear the planets should have moved away from their original birthplace towards the star. In the talk I will give an overview of our present understanding of the migration of planets induced by planet-disc interaction. The basic underlying theoretical concepts as well as the observational evidence will be presented.

Primary author(s): KLEY, Wilhelm (Universität Tübingen)

First steps of planet formation around very low mass stars

The very first steps of planet formation in disks around very low mass (VLM) stars are still not understood since the physical conditions are extremely unfavorable. In particular, the dust radial drift velocities are higher in disks around VLM stars than around T-Tauri stars, depleting the disk in grains before they can grow. However, there is observational evidence of grain growth in disks around VLM stars and Brown Dwarfs, and therefore somehow the radial drift of the particles must reduced or completely suppressed in these disks. For stopping the radial drift and trapping dust particles, the most common explanation is embedded massive planets in the disk forming pressure bumps. However, for disks around VLM stars, at least a Saturn mass planet is required to open a gap in the gas surface density and to trap millimeter-sized particles, which is challenging because Saturn mass planets are far above the present-day planet forming capabilities of these disks. In this talk, I will present our observational and theoretical efforts to understand the first steps of planet formation in the extreme environments of disks around VLM stars.

Primary author(s): PINILLA, Paola (MPIA)

Warm-start planets from core accretion, and H alpha from accreting planets: Thermal and radiative properties of the accretion shock

In the core-accretion formation scenario of gas giant planets, most of the gas accreting onto a planet is likely processed through an accretion shock. This shock is key in setting the forming planet's structure and thus its observable post-formation luminosity, and the radiative feedback can change the thermal and chemical structure of the circumplanetary and local circumstellar disc. Also, direct evidence for ongoing accretion has been provided very recently for PDS 70 b and c, and more forming planets are expected in the near future thanks to ongoing and new searches with e.g. SPHERE or MUSE. We present the first dedicated radiation-hydrodynamical simulations of the planetary accretion shock, using non-equilibrium radiation transport with up-to-date opacities (Marleau et al. 2017, 2019). We derive shock properties for a large grid of parameters. We find that usually, the temperature of the shock is given by the "free-streaming" limit. At very high accretion rates, the massive Rosseland opacity of the gas raises the shock temperature dramatically, an effect which has not been discussed explicitly before. We compare these results to original semi-analytical derivations. Additionally, we compute the fraction of the total accretion energy that is brought into the planet and find it is significant compared to the internal luminosity, supporting the hot-start scenario and suggesting that young planets are luminous. Finally, using the non-LTE radiation-hydrodynamics code of Aoyama et al. (2018), we present the first predictions of hydrogen-line emission (H alpha, Pa beta, Br gamma, etc.) from the accretion shock on the surface of the planet (Aoyama, Marleau et al., in prep.). We compare with PDS 70 b and c and derive joint constraints on each planet's mass and accretion rate.

Primary author(s): MARLEAU, Gabriel-Dominique (Universität Tübingen); AOYAMA, Yuhiko (Department of Earth and Planetary Science, University of Tokyo); KUIPER, Rolf (Universität Tübingen); IKOMA, Masahiro (Department of Earth and Planetary Science, University of Tokyo); MORDASINI, Christoph (Universität Bern)

Influence of grain growth on the thermal structure of protoplanetary discs

The thermal structure of protoplanetary discs is regulated by the opacities that dust grains provide. However, previous works have often considered simplified prescriptions for the dust opacity in hydrodynamical disc simulations, for example by considering only a single particle size. In the present work we perform and show the results of 2D hydrodynamical simulations of protoplanetary discs where the opacity is self-consistently calculated for the dust population, taking into account the particle size, composition and abundance. The simulations include the effects of grain growth in general and composition effects around icelines to calculate the thermal structure of the disc, which allows us to calculate the grain size distribution self-consistently. We compare simulations utilizing single grain sizes to two different multi-grain size distributions at different levels of turbulence strengths, parameterized through the alpha-viscosity and gas surface densities. We find that the grain sizes dominating the opacity of the disc and thus the thermal structure, increase with increasing orbital distance to the central star. This means that assuming a single dust size leads to inaccurate calculations of the thermal structure of discs. With the more accurate prescription that we are using, we investigate the dependency of the water iceline position on α. Our model opens up new avenues for protoplanetary disc simulations and planet formation, because the inclusion of a feedback loop of grain growth, realistic opacities and thermodynamics allows for more self-consistent simulations of accretion discs, which influences the growth of planets in these environments. Additionally, our here presented method can have important implications of relating observations of protoplanetary discs to disc structure simulations.

Primary author(s): SAVVIDOU, Sofia (MPIA)
Co-author(s): BITSCH, Bertram (MPIA); LAMBRECHTS, Michiel (Lund Observatory)

Retrieving the atmospheric parameters of young,cloudy gas giants

The atmospheres of newly formed planets may harbor clues that allow us to unlock their formation history.Depending on the mass and formation pathway of the planet, the metal enrichment of their atmospheres canbe dominated by either gas or solid body accretion.It is therefore desirable to estimate the metallicity of exoplanet atmospheres, as well as certain atomic abun-dance ratios, for example C/O.While the former could help to constrain the importance of solid accretion, the latter may provide hints onwhere in a disk a planet formed.One major problem for such inferences is that the spectra of young and cloudy self-luminous planets are no-toriously hard to interpret.Synthetic spectra obtained with self-consistent codes differ in their cloud model implementation, are proneto numerical instabilities due to radiative cloud feedback, and can lead to contradicting results. In my talk, Iwill present an alternative way to interpret spectra, namely by freely retrieving the atmospheric tempera-tureand cloud structure.This is done by employing the spectral synthesis code petitRADTRANS, which can treat clouds and scattering,and cou-pling it with a Bayesian parameter estimator such as MCMC or Nested Sampling. I will show somefirst results combining data from GRAVITY, SPHERE and GPI, and will give an outlook of how this frameworkis going to be applied in the future.

Primary author(s): MOLLIÈRE, Paul (MPIA)

Cosmic Masers

Room 9.12
Content: Cosmic masers naturally occur in the interstellar medium, stars and as extragalactic mega-masers. The most popular ones in the radio and (sub)millimetre wavelength range are formed by OH, water, SiO and methanol molecules. Due to their high brightness and compact nature, masers are one of the best existing tools for studying the kinematics and the physical conditions of regions that are hidden in dense environments. In our Galaxy, maser emission is typically found in star-forming regions and evolved stars, and enables us to reach the smallest regions of neutral gas lying close to the central objects like protostars or AGB stars.

In the AG 2019 splinter session "Cosmic Masers" we want to present a diversity of maser studies, summarizing the newest discoveries in this field, presenting recent observations of high-frequency masers, magnetic field studies via polarization measurements, variability behaviours of emission and the scenarios behind them, as well as studying infrared counterparts.

We invite you to join the session, where we can uncover the invisible!

Masers as the best tool in astrometry and kinematics studies - review

High angular resolution studies of maser emission at radio wavelength range are one of the best tools for deriving kinematics of hidden regions like dense environments around high-mass young stellar objects or evolved stars. The very long baseline interferometry (VLBI) owing to its milliarcsecond resolution and sensitivity of a few mJy provides most detailed information concerning astrometry and proper motions. I will summarize the recent results from "maser world" connected with stellar evolution: infalling envelopes, outflowing material, rotating discs. Trigonometric parallax measurements to distant objects in the Galaxy will also be presented.

Primary author(s): BARTKIEWICZ, Anna (Torun Centre for Astronomy)

Discovery of new maser transitions of methanol during the flare in G358.931-0.030

The high-mass star-forming region, G358.931-0.030, experiences strong maser flare from mid-January 2019 until now, reaching flux densities of thousands Jy. This event is monitored by the single-dish telescopes and observed with interferometers under international collaboration, the M2O collaboration. Specific feature of this event is that it gave birth to many previously unknown and highly excited maser lines of methanol. For example, torsionally excited class Il maser transition at 20.97 GHz gives birth to the line with flux density of a few thousand Jy and appears to be brighter than the maser line at 6.7 GHz. This was never observed previously. I will report on detections and observations of the new methanol maser transitions in G358.931-0.030 and provide interpretation of characteristics of this maser flare when it appears to be possible.

Primary author(s): SOBOLEV, Andrey (Ural Federal University)
Co-author(s): M2O COLLABORATION

Contribution of maser line spectroscopy to testing hypotheses about the processes of high-mass star formation.

Mechanisms of forming high-mass stars are one of the important unresolved issues of modern astrophysics. Recent detections of powerful bursts of maser emission in two high-mass star forming regions (HMSFRs) have opened a new window to investigate the role of non-continuous accretion in star formation processes. We will report on current monitoring projects conducted with the Torun 32m radio telescope which characterized the long-term behavior of maser lines associated with HMSFRs including extraordinarily bursts in two objects.

Primary author(s): WOLAK, Pawel (Nicolaus Copernicus University)

From maser polarization to magnetic fields

Masers will partially polarize through interaction of their radiation with the aligning magnetic field. The linear polarization of maser radiation can be used as a probe for the magnetic field direction, and its circular polarization as a probe for the magnetic field strength. Additionally, molecular masers occur in interesting parts of (high-mass) star-forming regions or evolved stars, where information on the magnetic field is important for understanding their dynamics. In this talk, I will present recent work on the molecular Zeeman parameters of methanol, a maser specie which occurs in (high-mass) star forming-regions. Computing methanols Zeeman parameters allowed us to perform the proper (re-)analysis of 10 years of methanol maser observations, which was not possible before due to the missing Zeeman parameters. I will also present the results of a new radiative transfer code that performs proper quantitative modeling of the polarization of maser radiation. I will present results of the maser polarization modeling of different molecules, that will help in translating the polarization information from maser signals into information on the magnetic field morphology and strength around their associated astrophysical objects.

Primary author(s): LANKHAAR, Boy (Chalmers University of Technology); VLEMMINGS, Wouter (Chalmers University of Technology)

Infrared observations of Class II methanol maser sources

Thermal infrared imaging revealed the association of Class II methanol maserswith luminous young stellar objects. At FIR wavelengths an almost ubiquitous association of 6.7 GHz methanol masers with dense cores was found. These masers are excellent tracers of massive star formation and often show variability or even periodicity. Only recently, the temporal relationship between the radio and infrared emission could be revealed for about a dozen of objects. Their correlation points to radiative excitation, in agreement with theory. However, the variability pattern of the various maser spots can be quite complex. This is due to the light echo nature of the stimulated maser emission. It has to be taken into account when trying to locate the masers with respect to the exciting source based on their time delays. The interpretation of the joint IR and maser variability is further complicated by fact that the optical depth for the IR radiation toward the observer might be different from that toward the masers. A few examples and new results will be shown to illustrate these topics. The prospects for IR monitoring of maser sources will be addressed as well.

Primary author(s): STECKLUM, Bringfried (Thüringer Landessternwarte)

Near infrared K-band monitoring of young stellar objects in vicinity of flaring maser sources

The contemporal observations of infrared (IR) emission variations and maser flares have been performed only for a few massive young stellar objects (MYSOs) (S255IR, NGC 6334I, G107.298+5.64) in recent years. We aim to use the near infrared (NIR) observations as more available instrument for monitoring of a larger number of MYSOs and for alert observations during rapid maser variation events. Note, the MYSOs are deeply embedded in parent cloud and the relevant emission is usually far infrared. But the NIR emission, observable in the part of the MYSOs, can be a tracer of those processes in MYSO environment that can lead to the maser variation. For example, we observe cyclic raises of K-band emission in G107.298+5.64 which are accompanied by periodic methanol maser flares, similar to the mid-infrared emission; but K-band emission appears in the more compact region. We report the results of our pilot two-year near-infrared K-band observations of MYSOs with the flaring maser sources in vicinity. The observations took places in Caucasian Mountain observatory of Sternberg Astronomical Institute with the new 2.5 meter telescope. The kind of the relation between variation in IR and maser lines can be different for different objects and maser species. For instance, we detected the dip in K-band emission during recent super-flare of water maser in G025.65+1.05. We suggest that the water maser flare can be better explained by the major role of maser sink rather than pumping: the sink can become more efficient in the lower IR radiation field. So, we provide observations of water masers in 22 GHz with 22-meter telescope of Pushino Radiastronomical observatory and 6.7 GHz methanol masers with 16-meter telescope of Ventspils observatory for target objects. Analysis of masers variability was supported by the RSF (Grant 18-12-00193), analysis of IR observations – by RFBR (Grant 18-32-00314).

Primary author(s): BISYARINA, Anastasia (AO UrFU); SOBOLEV, Andrey (AO UrFU); TATARNIKOV, Andrey (SAI MSU); ABERFELDS, Artis (Ventspils University of Applied Sciences); SHMELD, Ivar (Ventspils University of Applied Sciences); TOLMACHEV, Alexander (Lebedev Physical Institute)

Variable methanol maser in G111.256-0.770

Methanol masers, due to high brightness and low GMC extinction on 6.7 GHz are useful for studying physical properties of massive young stellar objects (MYSO). Since CH 3 OH masers are pumped by the IR photons, bursts and rapid variations of maser emission can be a good tracer of eg. accretion bursts. Observations of methanol masers in G111.256-0.770 revealed constant decrease in observed integrated flux density, superimposed on high - amplitude variability on a timescale of 5-6 yr. Variations of methanol maser integrated flux density appear to be correlated with those of IR flux observed with the NEOWISE, supporting radiative pumping scheme.

Primary author(s): DURJASZ, Michał (Nicolaus Copernicus University)

Measuring molecular gas on scales showing evolution in action with (sub-)mm masers

Maser emission from water, hydroxyl, methanol, silicon monoxide and other molecules can reach brightness temperatures $>$ 10 10 K. Radio interferometry observations can achieve sub-pc precision for discs around black holes and trace sub-au scale interactions in protostellar discs and the regions where evolved star winds reach escape velocity. Such kinematic studies have been used for decades at cm-wavelengths, but reconstructing physical conditions is difficult from just one or a few lines. (Sub-)mm imaging with ALMA, and now NOEMA, have expanded the possibility of observing multiple transitions, constraining temperature, density and other parameters on scales an order of magnitude finer than can be achieved using thermal lines. This is possible thanks also to the recent extension of models up to a few THz, and the first detections of THz water masers were made using SOFIA in evolved stars and a star-forming region. Masers can be used to address basic questions in physics, from their potential to diagnose shocks to measuring turbulence; the micro-arcsec resolution at cm wavelengths of RadioAstron could be achieved from the ground at mm wavelengths - or even surpassed by space VLBI. I will review such recent highlights and the potential of ground- and space-based interferometry for multi-wavelength and high frequency maser studies.

Primary author(s): RICHARDS, Anita

Masers in the envelopes of evolved stars

When envelopes of AGB stars are oxygen-rich, they may produce strong maser emission of one or more molecules, such as OH, H2O, or SiO, which commonly appears stratified, with the SiO masers located close to the stellar surface, water masers in the range of about 10-100 AU, and OH masers farther away, up to 10,000 AU from the central star. A new class of post-AGB stars dubbed water fountain-nebulae exhibit high-velocity water masers that trace a jet-like bipolar outflow. It is thought that such collimated outflow is responsible for the creation of bipolar cavities in the CSE of post-AGB stars, which lead to the formation of bipolar morphologies in the PN phase. Studying the water maser emission of different transitions is necessary to understand the physical properties of the collimated bipolar outflow and its interaction with the CSE. In this talk I will present the current status of the observational study of this type of masers in evolved stars and how they have helped us to understand the shaping of bipolar morphologies in their circumstellar envelopes.

Primary author(s): TAFOYA, Daniel (CHALMERS)

Variability of water masers in evolved stars on the timescale of decades

We will present conclusions on the properties of 22 GHz water maser emission in evolved stars based on 25 years of monitoring in Mira variables and Red Supergiants with the Medicina 32-m and Effelsberg 100-m antennas. The insights provided by a long monitoring period are evident, especially when complemented with occasional interferometric observations. The 'single-dish-only' observations show the presence of variations on timescales of decades, which likely are connected to structural changes in the circumstellar shells of the stars. Such variations include strong intensity flares lasting several months and systematic velocity gradients of maser components developing over years, as well as other secular variations which are superimposed on periodic variations following the stellar light variations. Future single-dish monitoring programs combined with properly placed interferometric observations will allow to study detailed motions of the stellar wind within the circumstellar shells.

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SOFIA Measurements of Nearby Galaxies and the Central Molecular Zone of the Milky Way

Room 47.02

Content: The SOFIA data are from the completed "joint impact proposals" on M51 and the Central Molecular Zone (both complete velocity resolved maps in [CII]), several GREAT and FIFI-LS observations of a number of individual galaxies (M 82, M51, IC 342, IC10, NGC6946 and the Large and Small Magellanic Clouds) and the recently started survey program of a large sample of nearby galaxies. These results, in combination with maps of the carbon monoxide molecule, atomic carbon, radio continuum and where possible, optical images are compared with models of galactic evolution and to determine the star formation rates, element abundances, ionization state of the ISM and the details of stellar processing. The splinter will provide a platform for the collaborators of the above projects, including PhD students, to present first results and to stimulated the interest of the larger community in these results.

SOFIA GREAT Observations of [OI] in the Circumnuclear Ring Region of the Galactic Center

We have used the up-GREAT Low and High frequency arrays to map the [OI] emission at 63 microns and the [CII] emission at 158 microns in the central 5 pc of the Circumnuclear Ring around the 4E6 M(Sun) Black Hole. With an angular resolution of ~ 6 arcsec, a spectral resolution of a few Km/sec and a sensitivity better than previous published results the [OI] data give us new insights into the neutral material in the region around and falling on to the Black Hole. I will summarize the previous observations of this region and discuss some of the new results.

Primary author(s): BECKLIN, Eric (SOFIA/USRA)
Co-author(s): GUESTEN, Rolf; RIQUELME, Denise (MPIfR); MORRIS, Mark (UCLA)

Large scale mapping of the Central Molecular Zone: C+ and CO emission

Large scale, high sensitivity surveys of spectral lines towards the Central Molecular Zone (CMZ, i.e., the central 500 pc of the Galaxy) will contribute substantially to our knowledge of the processes in the Galactic Center. We are mapping several molecular lines in the complete CMZ using the PI230 receiver at APEX telescope, and the [CII] emission using the upGREAT receiver onboard on SOFIA telescope. These observations will reveal gas flows at large scales (important for the fueling and star formation history of the Galactic Center) and between clouds, physical and chemical properties, the fraction of "CO-dark" gas, and address the known (current) lack of star-formation in the Galactic center. They will thus help to establish the Galactic Center as a template for the interpretation of observations in the cores of other galaxies.

Primary author(s): RIQUELME, Denise (MPIfR); GUESTEN, Rolf; HARRIS, Andrew (University of Mariland); COLOMBO, Dario (MPIfR)

The cycle of star formation and ISM transport in the CMZ

Within the central few hundred parsecs of the Milky Way, extending from longitude $l = -1° to 1.5°$, lies the Central Molecular Zone of the Galactic Centre. This extraordinary region is defined by a diverse variety of ISM features in numerous stages of evolution, including molecular clouds with volume densities of $10^4\,\mathrm{cm}^{-3}$, significantly above those found in the disk. The CMZ contains $3-5\times10^7 M_\odot$ of molecular gas, corresponding to around 5-10 of the content of the entire galaxy, and a similar fraction of its infrared luminosity. Gas temperatures, pressures and turbulent mach numbers are also significantly raised here, providing one of the more extreme environments for star formation within our observational reach. We have hence been provided with a unique laboratory for probing the effects of these environments on the interplay between the ISM and star formation, and high resolution observations of both individual features and the large-scale structure of the CMZ can improve our understanding of the formation and evolution of this region, which we can then apply to similar regions in nearby galaxies. This presentation will review the historical and recent advancements in our observational and theoretical interpretations of the CMZ, including those from and inspired by SOFIA. Topics will include the morphologies, dynamics and processes occurring in the ISM and massive stellar populations in the central few hundred parsecs. A particular focus will be on the multi-scale nature of the CMZ, and how episodic cycles of matter transport, star formation and Sgr A* activity might be linked in a coherent model, which can also explain the presence of many of the features observable today.

Primary author(s): BRYANT, Aaron (University of Stuttgart)
Co-author(s): KRABBE, Alfred (Deutsches SOFIA Institut, University of Stuttgart)

FIFI-LS observations of the Circumnuclear Ring. Probing the high-density phase of the PDR.

We investigate conditions in the 3-10 pc circumnuclear ring (CNR) in the center of our milkyway. Far-infrared (FIR) diagnostic lines obtained with FIFI-LS are used to probe the hot and dense phase of the photodissociation region exposed to the radiation field of the central population of massive stars. We use emission line flux maps from ionized ([CII] 157.7), atomic ([OI] 63.2, [OI] 145.5) and molecular (CO J=14$\rightarrow$13 186) species for a comparison with model predictions for PDRs. We also present spatially resolved maps of dust temperature, atomic hydrogen column density and far-infrared flux. The derived atomic hydrogen column density map is aligned with the galactic plane and extends spatially beyond previous near-infrared and radio based AV determinations. The atomic hydrogen column densities range from $10^{22.5}$ to $10^{23.1}$ cm^{-2}. We derive a [OI] 63.2 absorption map that is aligned with the galactic plane with no or little absorption in the northern lobe of the CNR but moderate absorption in the southern lobe of the CNR, which is consistent with the picture where the illuminated front surfaces of gas clouds in the northern lobe are directly visible to us, while in the southern lobe the illuminated surfaces are hidden by the clouds within the lobe itself. Local gas densities in the CNR are generally below the Roche limit.

Primary author(s): ISERLOHE, Christof (Deutsches SOFIA Institut, University of Stuttgart)

Combined velocity-resolved C+ and dust polarization observations of 30 Doradus.

We present a 400 arcmin^2 map of the velocity-resolved C+ emission toward 30 Doradus super stellar cluster in the LMC. The C+ emission observed with the UPGREAT receiver delineates shell structures around large-scale bubbles filled with hot, X-ray emitting gas ultimately produced by the strong stellar feedback from tens of massive stars in the region. We present a preliminary analysis of the gas velocity field and compare it with the orientation and strength of the magnetic field inferred from polarization observations at 154 μm and obtained with SOFIA/HAWC+.

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What can we learn from FIFI-LS fine structure line mapping? - Some examples of nearby galaxies observed with SOFIA

The Field Imaging Far Infrared Line Spectrometer (FIFI-LS) on SOFIA offers efficient mapping of fine-structure lines that allow probing star forming regions since they do not suffer from obscuration from foreground clouds. Working on the fast SOFIA telescope FIFI-LS is best suited to map relatively bright lines over large areas in extragalactic sources. The talk will outline some examples of the FIFI-LS guarantied time program on nearby galaxies probing the neutral and ionized interstellar medium. Mapping large regions of galaxies is important understand how the emissivity of the key [CII] line varies as a function of galactic environment. This is important to understand the heating and cooling balance in the ISM but also to gauge the use of CII as a SFR tracer in galaxies. For [CII] we will present current FIFI-LS results on the full disk mapping in the face on spiral Galaxy NGC 6949. We will also preview data on the [CII] mapping projects in NGC 3627, NGC 4321 and M83.
To showcase FIFI-LS ability to investigate ionized gas we will also present data of the [OIII] line at 52 μm in the star burst galaxies M82 and NGC 253 and He 2-10 taken with FIFI-LS. Together with the [OIII] line at 88 μm this provides a temperature independent probe of the electron density in the HII regions. The velocity resolution of FIFI also enables us to identify and investigate emission from phenomena like outflows in M82 and NGC 253.

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Unraveling the Evolution of the Interstellar Medium and Star Formation in the M51 Grand-Design Spiral Galaxy with SOFIA

We present results on a joint impact project to map the entire extent of the M51 grand-design spiral galaxy in the [CII] 158um line with the upGREAT and FIFI-LS instruments on SOFIA. The [CII] 158um line is an important tool to diagnose the physical state of the ISM as it can reveal the distribution of the gas that is in the transition between atomic and molecular phases, including the CO-dark H2 gas (hydrogen is molecular, but carbon is not, resulting in this gas being traced neither by CO nor by HI). Additionally, the [CII] line is an important tracer of star formation in galaxies. In this talk we present results on the distribution of star formation activity in the disk of M51 and its companion galaxy M51b. We will also present results on the distribution of [CII] across M51 and on the relationship between the different constituents of the ISM traced by FUV, Halpha, CO, HI, and [CII] emission both spatially and spectrally in the arms and interarm regions of M51

Primary author(s): PINEDA, Jorge (JPL)

Observing CII in external galaxies with upGREAT

Nearby galaxies where individual molecular cloud complexes can be resolved, while the large scale structure of the disk is observable, provide important stepping stones to relate observations of the ISM in the Milky Way with observations of galaxies farther away. The [CII] line is considered to belong to the strongest cooling lines of the ISM. In part it originates from the transition regions between the atomic and molecular gas and allow to study the physics, thermal balance, dynamics and the link to star formation of the ISM. However, the spatial extent of nearby galaxies, the faint emission and broad line widths make mapping nearby galaxies in CII as a whole or conducting a CII survey of nearby galaxies time consuming and difficult. Nevertheless, the 14 pixels of the upGREAT receiver onboard SOFIA together with the offer by the SOFIA project of large impact proposals and survey programs make such endeavors possible. The M51 joint impact program by Jorge Pineda has produced a complete, velocity resolved map of M51 in CII. Another project by Alberto Bolatto has started a survey, mapping a number of more distant galaxies in CII. However, the observation and reduction of velocity resolved CII data in external galaxies need special considerations and have their difficulties. This is e.g. due to low intensities, the broad line width of the CII lines and atmospheric lines that fall into the observed bandwidth (depending on the exact velocity of the observed object). In this presentation I will talk about strategies to optimize the observations and the reduction of velocity resolved CII lines in external galaxies with upGREAT and also present a few first results from the M51 large impact project and the galaxy survey project.

Primary author(s): BUCHBENDER, Christof (Universität zu Köln)

Result of SOFIA/upGREAT [CII] mapping of M51

We will present results of recent SOFIA/upGREAT [CII] mapping observations of M51. The observations were taken in the frame of a Joint Impact Proposal of the SOFIA Observatory. The SOFIA M51 observations provided the first spectroscopically resolved full [CII] map of M51. From these observation and complementary archival data we study the correlation between the [CII] 158 μm line and the different phases of the ISM, including atomic clouds, the ionized medium, dense and diffuse molecular clouds, and the transitional gas, the so-called CO-dark H 2 gas. The velocity-resolved maps allow us to separate the different ISM-contributions in velocity and, accordingly, to calculate the relative contributions of the above-listed phases to the integrated [CII] line intensity. The results are compared with the Herschel observation in [CII] of the Milky Way. We find significant [CII] from diffuse material between the spiral arms.

Primary author(s): ZIEBART, Monika (Universität zu Köln); OSSENKOPF-OKADA, Volker (Universität zu Köln); BUCHBENDER, Christof (Universität zu Köln); STUTZKI, Jürgen (Universität zu Köln); PINEDA, Jorge (JPL); GOLDSMITH, Paul (JPL) ; ON BEHALF OF M51 PROJECT TEAM

M51-like galaxy simulations: the role of the interaction on the star-forming molecular gas

We perform high resolution AREPO simulations of an M51-like galaxy aimed at the study of the dense molecular phase of the ISM in the larger galactic-scale context. By including important physics like star formation, stellar feedback, a non-equilibrium chemical network and self-shielding from UV radiation, we are able to follow in great detail the formation and destruction of GMCs. In this first study we address the impact of the interaction on the star formation activity of the system. In particular we focus on the following central question: is the interaction the main driver of star formation in an M51-like galaxy?

Primary author(s): TRESS, Robin (ZAH Heidelberg)

Studying the Interstellar Medium of Local Group Galaxies with SOFIA

Understanding the multi-phase structure and physical conditions in the zoo of galaxies living in the local universe is what SPICA will bring to us in unprecedented detail. Until the launch of SPICA, and in preparation for SPICA science, the FIR capabilities we have to study the diffuse and dense gas phases in galaxies, are with the SOFIA telescope. We exploit the FIFI-LS imaging spectrometer on SOFIA to map out the valuable FIR fine structure emission line diagnostics in Local Group galaxies. We analyse the observations of [OIII] 88 and 52 microns, [CII] 158 microns, [OI] 145 and 63 microns emission lines which we have mapped in IC10, NGC1569 and the Large Magellanic Cloud, to probe the properties of the low metallicity ISM. These new SOFIA maps allow us to characterise the properties of the evolving ionized and neutral gas phases of galaxies, ISM porosity, photoelectric heating efficiencies, CO-dark molecular gas fractions, as well as the various dynamical processes that shape a galaxy.

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The Close AGN Reference Survey: Discovering a [CII] line excess in a multi-phase AGN-driven outflow

I present the first results from the Close AGN Reference Survey (CARS, www.cars-survey.org) of 39 nearby ($0.01 < z < 0.06$) Seyfert 1 galaxies. The survey consists of spatially-resolved multiwavelength observations from X-ray to radio including VLT/MUSE dataset. Feedback processes from the nuclear activity can substantially affect the interstellar media (ISM) of the host galaxy via photoionization and jet-driven shocks and turbulence. The main aim of the CARS project is to map the multi-phase ISM to quantify the AGN impact on the host galaxies. In particular, the [CII] 158-micron far-infrared emission line is linked to different gas phases of the ISM including neutral and molecular gas and became an important ISM diagnostic for high-redshift galaxies. We have observed five CARS targets with FIFI-LS/SOFIA to check how reliable the [CII] line can be used as a star formation rate tracer for AGN hosts. The results reveal an unprecedentedly high [CII]/FIR ratio of ~ 4 in a mildly starforming (SFR $\sim$2 Msun/year) AGN host galaxy HE 1353-1917. The synergy with the multi-wavelength observations helps us to connect the [CII] emission with the physical processes in the host galaxy. HE 1353-1917 is an edge-on disc galaxy with the AGN ionization cone passing directly through the disc and producing a prominent extended narrow-line region photoionized by the AGN on kpc scales. Additionally, HE 1353-1917 contains a fast multi-phase jet-driven outflow with speeds up to 1000 km/s at $\sim$1 kpc distance from the nucleus. The [CII] line excess of an order of magnitude is apparently linked to the outflow in which the [CII] line is boosted due to the interaction of the powerful outflow with the molecular gas in the disc. Our new SOFIA data gives us an opportunity to guide the interpretation for the origin of the [CII] emission for high-redshift AGN host galaxies.

Primary author(s): SMIRNOVA-PINCHUKOVA, Irina (MPIA)

Dynamical Evolution of Nearby galaxies from EDGE-CALIFA survey

We investigate the link between the dynamics and star formation of 238 CALIFA (Calar Alto Legacy Integral Field Area) nearby galaxies across the Hubble sequence. We analyse their stellar kinematics and mass distributions through the solution of the axisymmetric Jeans equations, Markov-Chain Monte-Carlo method, Principal Component Analysis (PCA) and k-means clustering technique. Our results show that the amplitude and the inner-rise steepness of the circular velocity curves (CVCs) of the galaxies well correlate with their stellar mass, metallicity, age, star formation rate, molecular mass and dark matter content. Further, spatially resolved BPT diagnostic diagrams of our CALIFA galaxies reveal that galaxy dynamics is tightly linked to galaxy quenching and evolution processes. Star-forming galaxies, which occupy the Blue cloud, are characterised by slow-rising CVCs. Strong-AGN and LINER (LINER: low-ionisation nuclear emission-line region) galaxies, members of the Green valley, show flatter and more round-peaked CVCs, respectively. The LIER (LIER: low-ionisation emission-line region) galaxies, dominating the Red sequence, have the steepest CVCs of the sample, presented by the most sharp-peaked circular velocity profiles. Our results indicate that the CVCs of the galaxies from late- to early-type systems transit in an evolutionary sequence, and support the working hypothesis that the increasing concentration in the inner part of a galaxy stellar system, along with mergers and secular evolution, produces an active massive nucleus that disperses angular-momentum-rich baryon and quench the star-formation process. Furthermore, we will present the preliminary results from the HI follow-up observations of EDGE (the Extragalactic Database for Galaxy Evolution) survey, which will allow us to investigate atomic gas and dark matter content of our galaxy sample.

Primary author(s): KALINOVA, Veselina (MPIfR)

The EDGE-CALIFA survey: kpc-resolved morphological quenching in nearby galaxies

Understanding how galaxies cease to form stars represents one the most outstanding challenge for all galaxy evolution theories. One of the main mechanism proposed to explain the star formation quenching is starvation, where gas is exhausted or removed via various phenomena as tidal stripping or AGN feedback. The synergy between the Calar Alto Legacy Integral Field Area (CALIFA) and the Extragalactic Database for Galaxy Evolution (EDGE) surveys represents one of the best way to study the changes of the star formation efficiency in the local Universe on the resolved point of view: CALIFA provides information on the stellar populations and nebular emission lines for a sample of more than 600 galaxies, while EDGE supplies kpc-scale observations of the raw fuel of the star formation, the molecular gas, for 126 CALIFA targets. In this talk we show the evolution of the molecular depletion time across 6360 individual EDGE-CALIFA galaxy lines-of-sight, which decreases, on average, along the Hubble sequence. This appears to be a direct consequence of the increment of the star formation surface density from early- to late-type galaxy morphologies that is not followed by a similar trend in the molecular gas surface density. Hubble types correlates also with the average orbital time of the galaxies in our sample, that points towards an enhanced importance of the shear to prevent the collapse of local over-densities in the molecular medium. Altogether, these evidences support a “morphological quenching” scenario: infrared-bright galaxies do not lack the raw star formation fuel, but the growth of a bulge or spheroid in the center of the galaxies can stabilize the gas against collapse, stopping the formation of new stars. Furthermore, we will introduce the EDGE-APEX survey which is observing in CO lines the center of 300 more CALIFA galaxies.

Primary author(s): COLOMBO, Dario

New Challenges in Stellar Spectroscopy - Part 2

Room 47.06

Content: Accurate determination of the parameters of stars is of fundamental importance for many fields of astrophysics such as exoplanets, Galactic structure, and cosmology. The quantitative analysis of stellar spectra has a long history in Germany. Especially in the last decade, a significant progress has been made thanks to advanced theoretical model atmospheres for cool and hot stars, the availability of excellent spectroscopic data from X-ray to infrared, improved atomic and molecular data, and the increase in computing power.

Large spectroscopic, astrometric and photometric stellar surveys such as 4MOST, Gaia or LSST, are revolutionising the field. However, these crucial developments in observational astronomy pose major challenges for the application of the sophisticated theoretical methods to the data. Processing and analysing millions of stellar spectra calls for automated approaches with large model grids and systematic uncertainties due to unavoidable simplifications need to be properly assessed. Besides, these large-scale stellar surveys expose a new kind of challenge — the enormous diversity of stellar objects in the Milky Way and beyond. Peculiar and interesting objects discovered in the new wealth of data, such as very metal-poor stars, red supergiants, or compact remnants of failed thermonuclear supernovae, require tailor-made models and individual analyses.

In connection to that several problems need to be addressed: How can accurate distances and multi-band photometry be combined with spectroscopic analyses in a most efficient way? What are the synergies between spectroscopy and the emerging field of asteroseismology? How do new stellar structure models compare with parameters derived by combining model atmospheres and observations? And finally, how can we best exchange and publish our data, models and codes to make them available for the next generation of researchers in the field?

In this splinter session we aim at gathering the stellar community to present most recent results both in observation and theory. While the focus will be on stellar spectroscopy, alternative methods of quantitative analyses of stars will be discussed as well.

Chemical abundance analysis of the open cluster NGC2420

Transport processes in stellar interiors are thought to be an important ingredient in modelling stellar structure and evolution. Making use of the Gaia-ESO spectra, we perform a detailed chemical abundance analysis of the open cluster NGC 2420. With an age of around 2.5 Gyr and slightly sub-solar metallicity, NGC 2420 occupies an interesting regime of the parameter space to study atomic diffusion. We also account for Non-LTE effects in the abundance analysis. We find that the stellar surface abundances show characteristic trends with the evolutionary stage of stars. We compare the observed abundance trends with the predictions of the stellar models, which include gravitational settling, radiative acceleration, and additional mixing, to constrain the efficiency and origin of these transport processes.

Primary author(s): SEMENOVA, E. (MPIA)

Detecting emission line objects in globular clusters

More than one million spectra of stars in 27 Galactic globular clusters have been collected with the integral-field spectrograph MUSE at the VLT. These spectra are extracted from the observed 3D datacubes and are fitted against a grid of synthetic spectra. An automatic search for emission lines in the residuals of the fitted spectra results in a set of unusual stars and extended objects.
This includes the newly discovered remnant of a 2,000-year-old nova in M22, companions of known stellar-mass black holes, cataclysmic and other variable stars, optical counterparts to known X-ray sources, close binary systems with mass transfer, and background galaxies. This catalog of emission-line stars in globular clusters compliments existing datasets on X-ray and radio sources and helps classifying the underlying stellar systems.

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A MUSE view of the multiple populations' chemistry in Galactic Globular Clusters

Stars in Galactic globular clusters are known to exhibit abundance variations in specific elements such as He, C, N, O, Na, and Al. These variations can be observed via spectroscopy but also photometrically using CMD constructed with different filter combinations. Although these multiple populations found in globular clusters have been and still are the subject of many investigations, the origin of their elemental abundance variations still remain rather mysterious.
I will present some of our recent results on that topic based on the spectroscopic survey of 27 globular clusters that is currently carried out as part of the MUSE GTO time. With the MUSE survey covering the central regions of the clusters for which HST photometry is available, we can use these photometric catalogues to separate the RGB stars into two or more populations based on their position in the pseudo-two-color diagrams (or chromosome maps) introduced by Milone et al. Although the MUSE spectra are of relatively low resolution (R $\sim$ 3000) by combining the spectra of the stars within the distinct populations, we are able to study their abundance variations and relate them directly with the populations distinguished on the pseudo-two-color diagrams.

Primary author(s): LATOUR, M. (Universität Göttingen)

Observing short-period binaries with FORS2

The FORS2 instrument is one of the most widely used and productive instruments on the Very Large Telescope. It is still the only instrument providing low to medium resolution spectra in the optical at the VLT including also in the blue wavelength range below 400 nm. To observe blue, faint, short-period binaries, a telescope of the 8m-class is necessary, as the possible exposure time is limited. The spectroscopy mode of FORS2 is used mainly for deriving redshifts of faint galaxies or for taking multi-object spectra of stars in other galaxies or open clusters. However, the resolution of FORS2 is also sufficient to measure the radial velocity curves of close binaries. We were awarded with an ESO Large program with FORS2 for spectroscopic follow-up of the EREBOS project, which aims at increasing the number of eclipsing post-common envelope systems studied significantly. With the help of spectroscopic follow-up combined with photometric observations, we are able to determine the absolute as well as the orbital parameters of the post-common envelope systems to answer especially the question, which minimum mass a companion must have to be able to eject the envelope of the primary star in a common envelope phase, but also to understand the poorly understood common-envelope phase better. In the course of the analysis of the FORS2 data we phased some challenges, which we will also discuss in this talk.

Primary author(s): SCHAFFENROTH, V. (Universität Potsdam)

Volume-limited samples of hot subdwarf candidates for spectroscopic surveys

With the Gaia mission we have distances as accurate as never before. Also there are dust maps of the solar neighbourhood giving the extinction in this region. With this data we can classify stars in the solar neighbourhood regarding their spectral properties. We have done this with the hot subdwarf catalog. We took all hot subdwarf candidates in the solar neighbourhood and corrected their magnitudes with the new dust maps available. We then applied the selection criteria for hot subdwarfs to select volume limited samples. Further research can be done with those samples adding data from spectroscopic surveys such as 4MOST.

Primary author(s): POLEI, N. (Universität Potsdam)

Identifying Multiple Populations in AGB Stars

Globular clusters (GCs) are now known to host multiple stellar populations with differences in light element abundances. However, there has been some recent debate over whether or not these populations are found in the same percentages on the asymptotic giant branch (AGB) as they are for other evolutionary stages. We present our analysis of the CN and CH bands for AGB stars in the GCs M10 and M71 to explore this issue. We use measurements of CN and CH indices from low resolution spectra to identify multiple populations based on CN strength and calculate carbon and nitrogen abundances by modeling the CN and CH band regions. We find that the percentages of each population on the AGB agree well with the percentages found on the red giant branch (RGB) of each cluster when nitrogen abundances are used to distinguish between populations. We also find that the classification of AGB stars based on the CN band strength alone can be misleading as these stars have significantly lower carbon abundances than RGB stars of a similar luminosity. It is important to consider that lower carbon abundances affect the CN band strength, and not to assume that a weak CN band directly implies a low nitrogen abundance when classifying AGB stars.

Primary author(s): GERBER, J. M. (Indiana University Bloomington)

Thursday 19 September

Computational Astrophysics

Room 47.02
Content: Numerical simulations are a key pillar of modern research. This is especially true for astrophysics where the availability of detailed spatial and temporal data from observations is often sparse for many systems of interest. In many areas large-scale simulations are required, e.g., in support of the interpretation of observations, for theoretical modeling, or in the planning of experiments and observation campaigns. The need and and relevance of large-scale simulations in astrophysics is reflected in a significant share of 25-30% of the overall German supercomputing time. While the supercomputing landscape has been stable for a long time, it started to change in recent years on the path towards the first exascale supercomputer. New technologies such as GPUs for general purpose computing, ARM based platforms (versus x86 platforms), and manycore systems in general have been introduced and require to rethink and revisit traditional algorithms and methods.

This splinter meeting will bring together experts in computational astrophysics from all fields covering (but not limited to) fluid-based methods (from hydrodynamics to general relativistic magnetohydrodynamics), kinetic simulations, radiation transport, chemistry, and N-body dynamics applied to astrophysical systems on all scales, e.g., supernovae, planetary and solar dynamos, accretion disks, interstellar, circumgalactic, and intracluster media, or cosmological simulations.

The goal of this meeting is to present and discuss recent developments in computational astrophysics and their application to current problems. Thus, contributions involving large-scale simulations and new methods/algorithms are specifically welcome.
In addition to astrophysical results obtained from simulations, speakers are also encouraged to highlight numerical challenges they encountered and how they addressed those in their codes. These may include, but are not limited to, new algorithms (e.g., higher-order methods), changing HPC environments (e.g., manycore, GPUs, or FPGAs), or data storage (e.g., availability of space, sharing, or long term retention).

Empirical models and the galaxy-galaxy merger rate

The galaxy-galaxy merger rate is a critical component in constructing a complete picture of galaxy formation and evolution. Despite recent developments in observationally derived merger rates, there exists large uncertainties in translating observational quantities into true merger rates. We explore the galaxy-galaxy major merger rate in the frame work of the empirical model for galaxy formation, Emerge. With Emerge (Moster et al. 2018) we are able to make predictions about the growth of galaxies out to high redshift that can be observed with future deep field surveys. Here we define the rate, R as the percentage of galaxies that will merge with another similar sized galaxy (mass ratio 1:4) within some time interval. We find that between 2% and 6% of large galaxies (m $> 2\times10^{10}\ M_{\odot}$) will experience a major merger per Gyr. Generally, our results exhibit an increase in rate with increasing redshift up to $z \approx 2$, followed by a rapid decay at higher redshifts. The rates we determined through our model tend to be lower when compared with other theoretical models. However, we generally find very good agreement with recent observations, although the rates derived from our model tend to be flatter at higher redshifts. Finally, we show that merger rates computed from close galaxy pairs, as done for observed rates, over predict the true intrinsic rates by a factor of 2. This discrepancy has direct consequences for the interpretation of observed galaxy merger rates.

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Magnetic field amplification and star bursts induced by mergers of disk galaxies

Detailed numerical studies of interacting galaxies require elaborate modelling of realistic, multi- component systems in translational motion including live dark matter halos, gaseous disks, and the (live) stellar components such as disks and bulges. While the magnetohydrodynamics of the gas can be computed on the grid, (live) stellar and dark matter components require the computation of gravitational n-body dynamics and the utilization of particle-mesh techniques in order to continuously advance the joint gravitational potential of the entire system. Sub-grid scale modelling permits consideration of the effects of turbulence in the interstellar medium as well as star formation. This project focuses on the development of realistic galaxy models in order to study astrophysical effects connected to merging galaxies. We are especially interested in the evolution of the magnetic field and the H 2 fraction in the presence of turbulence, and their interplay with starbursts and star formation in general.

Primary author(s): SELG, Simon (Universität Hamburg); SCHMIDT, Wolfram (Universität Hamburg)

He and N enrichment in massive Main-Sequence stars: origin of WNL stars and the N evolution in high-z galaxies

The evolutionary paths taken by very massive stars, M $\gtrsim 60\,M_{\odot}$, remain substantially uncertain: they begin their lives as main sequence O stars, but, depending on their masses, rotation rates, and metallicities, can then pass through a wide range of evolutionary states, yielding an equally broad set of possible surface compositions and spectral classifications. To study the evolution of such stars, we cover a broad range in mass ($M/M_{\odot} = 60 - 150$), rotation rate (v/v crit = 0 - 0.6), metallicity ([Fe/H] = -4 - 0), and α- element enhancement ([α/Fe] = 0 - 0.4). We show that rotating stars undergo rotationally-induced dredge-up of nucleosynthetic products, mostly He and N, to their surfaces while still on the main sequence. Non-rotating metal-rich stars also reveal the products of nucleosynthesis on their surfaces because even modest amounts of mass loss expose their "fossil" convective cores: regions that are no longer convective, but which were part of the convective core at an early stage in the star's evolution. Thus surface enhancement of He and N is expected for rotating stars at all metallicities, and for non-rotating stars if they are relatively metal-rich. These stars also determine the N-evolution of the high-z galaxies. Understanding N/O evolution is essential in order to understand the chemical evolution of high-z galaxies. Observations show large scatter in N/O at low O/H in metal-poor galaxies, and it remained unexplained till date. Our models explain not only the origin of N-enrichment but also the aforementioned large scatter of N/O in high-z galaxies.

Primary author(s): ROY, Arpita; SUTHERLAND, Ralph (ANU); KRUMHOLZ, Mark (ANU); HEGER, Alexander (Monash University); DOPITA, Michael (ANU)

Advantages and disadvantages of approximate radiation transport methods: Enormous benefits or tremendous errors?

Context: Many astrophysical studies require an highly accurate treatment of radiation transport to properly determine heating and cooling timescales, observables, or dependent physical properties. At the same time the radiation transport algorithm should be as fast as possible to allow for an efficient usage of computing resources. Hybrid approaches try to combine the accuracy of a high-order radiation transport method with the speedup of sensible approximations.
Aims: We check the reliability of fast, approximate radiation transport methods for circumstellar disk studies by comparing their accuracy to previous standard radiation benchmark test results.
Methods: We compute the equilibrium temperature distribution in a setup of a central star and a slightly flared circumstellar disk, which is embedded in an optically thin envelope. We check the accuracy of the gray flux-limited diffusion (FLD) approximation and newly developed gray and frequency-dependent hybrid approximations. In the hybrid method, the stellar irradiation is computed via a gray or frequency-dependent ray-tracing (RT) step and the thermal (re-)emission by dust grains is shifted to a gray FLD solver. Results:

1. For moderate optical depths, a gray approximation of the stellar irradiation yields a slightly hotter inner rim and a slightly cooler midplane of the disk at larger radii, but is otherwise in agreement with the frequency-dependent treatment.
2. The gray FLD approximation fails to compute an appropriate temperature profile in all regimes of optical depth. For low optical depth, the isotropic assumption within the FLD method yields a too steep decrease of the radial temperature slope. For higher optical depths, the FLD approximation does not reproduce the shadow behind the optically thick inner rim of the circumstellar disk, yielding artificial heating at larger disk radii.
3. The frequency-dependent hybrid approximation yields remarkable accuracy for the whole range of optical depths, comparable to sophisticated Monte-Carlo radiation transport codes.

Primary author(s): KUIPER, Rolf (Universität Tübingen)

Resolving the galactic Dynamo of the Milky Way

We present simulations of isolated Milky Way-like galaxies including an explicitly modelled circum galactic medium (CGM) to investigate the amplification process of the magnetic field in a galactic dynamo and the possibility to drive large scale outflows driven by the magnetic pressure. The simulations are carried out with the Tree-Smooth-Particle-Magneto-Hydrodynamics (SPMHD)-code P-Gadget3 (Springel 2005, Dolag & Stasyszyn 2009, Beck 2016). The galaxy is setup in an idealised environment consisting out of a dark matter halo with a Hernquistprofile (Hernquist 1993), an exponential disc of gas and stars and a spherical bulge. The CGM is modelled via a β-profile which is constraint to the CGM of the Milky Way. Every supernova that goes of in the multi phase Interstellar medium (ISM) within the simulation seeds a small magnetic dipole. In this model we assume that magnetic fields are generated in stars and give back a certain amount of magnetic energy to the ISM when the star ends its life in a supernova. The magnetic field is amplified in a galactic dynamo and can be subdivided in three stages that are in agreement with theoretical findings of dynamo theory. The first amplification process is the adiabatic compression. Further, we identify an ordinary $\alpha - \omega$ dynamo that acts via small scale buoyant flows (α-effect) interacting with the shear of the large scale rotation (ω-effect). The third processes is the small scale turbulent dynamo. Turbulence is induced on small scales via the feedback of supernovae and can stretch, twist and fold magnetic field lines which leads to an exponential growth of the magnetic field. We quantify this dynamo process over the magnetic power spectra (Kazantsev-spectrum) and the curvature of the magnetic field lines and find good agreement with the theoretical predictions from Kazantsev (1968) and Schekochihin et al. (2004).

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A unified model for describing star formation, feedback, and star cluster formation and evolution within galaxy formation simulations

I will present our group's recent efforts in deriving new sub-grid models for star formation, feedback, and stellar cluster formation and evolution, which are used in our new EMP (for "Empirically Motivated Physics") suite of galaxy formation simulations. I will present results from the first applications of these models in galaxy simulations, as well as their validation using numerical simulations of star formation in galaxies at higher numerical resolution. I will demonstrate how these simulations provide an improved description of star formation in galaxies, and also explain the origin of globular clusters as the relics of regular star formation in high-redshift environments.

Primary author(s): KRUIJSSEN, Diederik (Universität Heidelberg)

Connecting observed galaxies and simulated dark matter haloes with a deep neural network

In the last decade, the field of artificial intelligence and machine learning has expanded rapidly. Recently, several machine learning methods developed by the data science community have been adapted for astrophysical problems. The big advantage of machine learning methods is that they give computers the ability to learn without being explicitly programmed. Whereas for classical numerical methods, such as hydrodynamic simulations and semi-analytic models we need to know all (complex) 'rules' beforehand, a machine learning algorithm can detect patterns automatically. This makes them the ideal tool for many analysis tasks and improvements in numerical astrophysics. Empirical galaxy formation models connect the properties of simulated haloes to those of observed galaxies. However, it is often unclear how these relations should be parameterised. Therefore we develop a novel method and adopt a deep neural network (DNN). The input nodes consist of different halo properties (e.g. halo mass and concentration), while the output nodes yield the galaxy properties (e.g. stellar mass and SFR). The model is implemented with TensorFlow and directly runs on NVIDIA Volta graphics cards, accelerated by tensor cores. Training the model on labeled data provided by the galaxy formation code EMERGE, galaxy properties can be reproduced very well. If we train the model directly on observed statistical data (e.g. mass functions, clustering) using a reinforcement learning approach with particle swarm optimisation, the DNN reproduces observations at least 10

Primary author(s): MOSTER, Benjamin (Ludwig-Maximilians Universität, München); O'LEARY, Joseph (Ludwig-Maximilians Universität, München); NAAB, Thorsten (MPA)

K-Athena – a performance portable structured gridfinite volume MHD code

Large scale simulations are a key pillar of modern research in many areas and require ever increasing computational resources. While the fundamental architecture of supercomputers saw little change for a long time, different novel architectures emerged in recent years on the way towards the exascale era. These include many-core processors such as the Intel Xeon Phi,FPGA accelerator cards, or GPUs for general purpose computing that can have thousands of cores per card. Until recently, each new architecture can require a separate, non-trivial rewrite of a simulation code. To circumvent this, a current goal in computational science is the creation of parallel programming paradigms for writing performance portable code: code that can run efficiently at high performance on many different supercomputer architectures. Kokkos is one example of a performance portable on-node parallel programming paradigm realized as a C++ template library. We combined Athena++, an existing radiation general relativity magnetohydrodynamics CPU code, with Kokkos into K-Athena to allow simulations to run efficiently on both CPUs and GPUs using a single codebase. I will present profiling and scaling results for multiple architecture including Intel Skylake CPUs, Intel Xeon Phis, and NVidia VoltaV100 GPUs. K-Athena achieves $> 10^8$ cell-updates/s on a single V100 for second-order double precision MHD, and a speedup of 30 up to 24,576 GPUs on Summit (compared to 172,032CPU cores) reaching 1.94×10^{12} total cell-updates/s at 76% parallel efficiency. Using a roofline analysis I will demonstrate that the overall performance is currently limited by DRAM bandwidth on both CPUs and GPUs. Based on the roofline analysis K-Athena achieves a performance portability metric of 83.1% across 5CPU generation, 4GPU generations, and IntelXeonPhis. Finally, I will present the strategies we used for implementation and the challenges we encountered while attempting to achieve maximum performance on different platforms. This will support other research groups to straightforwardly adopt this approach to prepare their own methods and codes for the exascale era.

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The Early Milky Way as seen through Galactic Archeology 2

Room 47.05

Content: There is no other galaxy that can be studied in as much detail as our own Milky Way. Only here can we study individual stars in great detail, both in their chemical abundance patterns and also in their kinematic and astrometric properties. By searching for distinct kinematic and chemical signatures, we can infer what the Galaxy was like at early times.

We are currently experiencing a revolution in the field of Galactic Archeology as a result of the Gaia mission as well as several large scale spectroscopic surveys (including multi-object spectrographs like WEAVE and 4MOST) that are either already ongoing or set to begin in the near future.

In this splinter session, we aim to bring together the German community working on various topics related to Galactic Archaeology (both theoretical and observational). Relevant topics include (but are not limited to):

- chemical abundance trends and kinematics of the bulge, disk and halo (observations and simulations)
- dwarf galaxies, stellar streams and substructure in the halo
- metal-poor stars
- (future) spectroscopic surveys and Gaia

Each of these individual topics (amongst others) are important to our understanding of the processes involved in formation and evolution of our Galaxy, but bringing them all together and placing them in context with each other is crucial in order to gain a big picture understanding of the (early) history of the Milky Way.

The chemical evolution of the Milky Way - a story told through heavy elements with CEMP stars

Stellar abundances are fossil records of the physical conditions in the interstellar medium and of the progenitors that created the material the low-mass stars formed from. Through spectroscopy of various stars we can use Galactic archeology to uncover the highest level of detail of what the Milky Way looked like several billions of years ago as well as how massive and energetic some of the first supernovae were. All heavy elements show a large star-to-star abundance scatter at low metallicities, which typically hides the fact that several processes and formation sites at early times created different amounts of a given element under different conditions. Using stellar abundances of e.g. carbon enhanced metal-poor (CEMP) stars, we can explore the neutron-capture processes and learn about the origin of the heavy elements from a number of formation sites that host these processes. I will discuss abundances of CEMP stars in which we have explored the behaviour of a large number of heavy elements. I will also present a new and faster way of deriving metallicities in CEMP stars and show how we can use Sr and Ba to classify them.

Primary author(s): HANSEN, Camilla J. (MPIA)

Galactic archaeology with dwarf galaxies

Dwarf galaxies are the most common type of galaxy in the Universe. Only in the Local Group are we able to obtain high-resolution, high signal-to-noise spectra of individual stars in such systems for a detailed chemical abundance analysis. Our Milky Way has likely experienced several major and minor mergers throughout its formation history, with dwarf galaxies of various sizes. The ancient dwarf satellite galaxies therefore provide a unique view into early chemical evolution. I will review the current status about chemical abundances in the Milky Way satellite galaxies, in particular in relation to carbon and the heavy elements (Z>30). These results I will put in context with theoretical predictions and early chemical enrichment in the Milky Way.

Primary author(s): SKÚLADÓTTIR, Ása (University of Florence)

Finding metal-poor stars with RAVE

I will give an overview on how to identify metal-poor stars in the RAVE spectroscopic survey and the resultsfrom high-resolution spectroscopic follow-up campaigns. The results are of particular interest consideringthat RAVE probes the same wavelength interval as Gaia-RVS, at a comparable resolution.

Primary author(s): STEINMETZ, Matthias (AIP)

Gaia's view of the stellar streams of the Galactic halo

Stellar streams hold great promise as tools to uncover the acceleration field in the Milky Way and to probe the incidence of dark matter substructure. In this talk I will review recent progress in this field with the new discoveries in Gaia DR2, and discuss the prospects with the upcoming Gaia data releases.

Primary author(s): IBATA, Rodrigo (ObAS)

Stellar streams in the solar neighbourhood

The publication of the Gaia DR2 catalogue gives us the unprecedent dataset to extend our knowledge of nearby kinematically cold structures, which may trace the dissolution of open clusters. This will ultimately shed light on the processes at work during the cluster dissolution into the field, as well as the Galactic gravitation potential shaping the tidal tails over hundreds of Myr. Here we report our study of the tidal tails of the Hyades cluster (Röser et al. 2019). We find a clear indication for the existence of the Hyades tidal tails, a leading tail extending up to 170 pc from the centre of the Hyades with 292 stars (36 contaminants), and a trailing tail up to 70 pc with 237 stars (32 contaminants). A comparison with an N-body model of the cluster and its tails shows remarkably good coincidence. Five white dwarfs are found in the tails. In this paper, we will also report our on-going work on similar nearby cluster.

Primary author(s): GOLDMAN, Bertrand (International Space University); RÖSER, Siegfried (ZAH); SCHILBACH, Elena (ZAH)

The the metal-poor Milky Way halo: The metallicity distribution function as seen by the Pristine survey

The metallicity distribution function of the Galactic halo contains a wealth of information about its formation processes. In particular, the relative abundances of the most metal-poor stars in the halo encode the rate of chemical enrichment at early times, and the signatures of past and current accretion events. The Pristine survey is a narrow-band photometric survey that targets the metallicity sensitive CaHK spectral lines, and is capable of assigning photometric metallicities to FGK type stars with a precision of ~ 0.2 dex. Using the current catalogue of $\sim 5 \times 10^6$ FGK type stars over a sky coverage of $\sim 2500\,\mathrm{deg}^2$, we build an MDF of the Galactic halo using a halo sample selected with distant MSTO stars, and a rescaling procedure using a complementary spectroscopic follow-up sample. Previous MDFs of the halo have relied predominantly on purely spectroscopically selected samples, and as a result have complex selection functions and small datasets. With the current sample, we find a significantly higher number of stars with [Fe/H] $<$ -2 than previous works, suggesting that the Galactic halo has a larger population of metal-poor stars than previously thought. At low Galactic latitudes, we identify a metal-rich population at the disc-halo interface, suggesting and extended disc, or a flattened (in-situ) halo component.

Primary author(s): YOUAKIM, Kris (AIP); STARKENBURG, Else (AIP)

Cusp to Core and everything in between: Corification of the DM halo and its effect on stellar substructures in dSphs

A way to solve the dark matter (DM) cusp-core problem is to consider the stellar feedback: star formation and supernovae explosions. In numerical simulations, when feedback is included initial cuspy DM halos can evolve to become flatten cored DM halos: I will call this process the "corification" of the DM halo. In principle one may think that the cusp-core problem was solved when considering the baryons. But one has to take into account that the corification of the DM halo is a process which takes (for galaxies with one stellar burst at the beginning of their lives) 14 Gyr to be completed i.e. it takes 14 Gyr to form a core. It has been found that in order to guarantee the survival of stellar substrucure (such as globular clusters) within dwarf spheroidal (dSph) galaxies a DM core is needed. I perform N-body simulations of the corification of a DM halo (as a background potential) and the survival of stellar substructures. In particular I model the dSph galaxy Eriadnus II.

Primary author(s): LORA, Veronica (IRyA (UNAM))

Astronomy and Education

Room 9.11
Content: The Bildungsausschuss of the Astronomische Gesellschaft has embarked on this splinter meeting to bring together young scientists working on the broad field of astronomy education. The aim of this splinter session is to exchange knowledge, experiences and ideas of how to bring fundamental issues and latest research into the classroom. In addition students working on their Exams or PhDs get the possibility to present and discuss their thesis and to get into contact with each other.

Stellar requirements for the emergence of life

The detection of extraterrestrial life would be perhaps the greatest physical sensation ever. But where to look? Is every planet suitable for the development of higher life? Can life form in any stellar system at all? In general, liquid water is used first and foremost for the habitability of a planet. In the right distance, liquid water can exist around every star. In this talk it is shown that a reduction of the question if liquid water exists ignores essential aspects, since other properties of the stars - in particular the time spent on the main sequence - also have a great influence on the possibilities of life on other planets. The presented ideas offer the possiblilty to treat some basics of astrobiology at school or at introductory courses for astrophysics at university.

Primary author(s): HOHMANN, Sascha

The New German ESERO Office: An Educational Effort by the European Space Agency ESA

In May 2018, Germany finally obtained an " European Space Education Resource Office", ESERO for short, which coordinates and promotes educational resources relating to or provided by the European Space Agency ESA. The headquarters of ESERO Germany are located in Bochum, at the Working Group Geomatics, which is part of the institut of Geography of Ruhr-Universität Bochum. Partners include, among others, the Astronomical Institutes in Bochum and Bonn, Bochum Planetarium, the Institute for the Didactics of Physics in Cologne and zdi.NRW. The main task of the network is the advancement of STEM education over the entire K-12 range through the development and distribution of of teaching material, concepts for innovative lessons and teacher training sessions. Obviously, a special focus is placed on ESA-related themes like Earth observation, astronomy and spaceflight. The first phase of implementation included the analysis of curricula of all STEM-related subjects (Physics, chemistry, biology, mathematics, computer science, geography), systematically identifying astronomical or space-related content. The talk will describe the basic structure and aim of ESERO and give a brief review of the resuts of the analysis of the curricula.

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Diversity of astronomical preconceptions in (strong) heterogeneous learning groups in the orientation level (grades 5 and 6) in Germany

Especially in the orientation level, learning groups are very heterogeneous, as the pupils come from different elementary schools and have treated different contents in the subject general science. In inclusive learning groups, the heterogeneity is further intensified. One of the tasks of the orientation level is the approximation of the prior knowledge acquired in primary school. However, there is almost no evidence yet of how various the (strong) heterogeneous or inclusive learning groups are in terms of their prior knowledge, and what preconceptions they bring with them to the orientation level physics lessons. This talk attempts to close this gap for the astronomical contents solar eclipse, lunar eclipse and the phases of the moon. Based on the preconceptions mentioned in the literature, this talk presents the results from an open questionnaire, which was answered by 341 pupils in (strong) heterogeneous or inclusive learning groups. The identified preconceptions and their distribution are presented. Conclusions for teaching practice in strongly heterogeneous learning groups will be discussed.

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Co-author(s): SCHULZ, Andreas (University of Bonn); HENNEMANN, Thomas (University of Cologne)

Climate Change for the School

Climate change is the greatest global challenge facing humanity in the 21st century andtherefore a relevant issue for today's students.In this talk I will present an LMU project that adresses the physical processescon-troling the Earth's global climate system and those which trigger climate change,all contained in an experimental "Climate-Kit" and a handbook for teachers.However, at least as important as understanding the physics of climate change is the need to act.For this reason, the project is also oriented towards initiating school projects that not only have an impact atschool,but also shape the individual and private lives of the students. This project has been endorsedby both the Enviroment and Education Ministry in Bavaria.

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Future Astronomical Opportunities in Stratosphere and Space

Room 9.41
Content: The goal of this splinter meeting is to evaluate the status and the future development of air- and spaceborne astronomy, particularly in Germany, and to offer a forum for corresponding exchange and discussions. The meeting especially welcomes representatives of all projects and efforts that overcome atmospheric limitations by leaving the ground, be they planned or currently active. Examples include the space missions PLATO, FIRI, ATHENA, and GAIA, or the airborne mission SOFIA.

A special focus of the meeting also lies on balloon-borne astronomy, which has become increasingly popular again in Europe and worldwide over the last 10 to 15 years, but is missing institutionalized support in Europe. In this regard, the meeting also aims at bringing together members of the European astronomical community with either experience or interest in balloon-borne observations, with a focus on discussing science cases and ideas for future missions as well as potential joint efforts to advance balloon-borne astronomy in Germany and Europe.

Gaia's star catalogues - A giant leap for astrophysics

Since 2014, ESA's Gaia satellite measures the positions of a huge number of stars of our Milky Way to gain a better understanding of stars, the structure and evolution of our home galaxy. On April 25, 2018, the second Gaia catalogue (Gaia DR2) was published: From more than 1.3 billion stars, the positions, motions, parallaxes (distances), magnitudes (brightnesses) and colors of the stars were determined with high precision. Additionally, Gaia centric observations of 14,000 asteroids, a catalogue of variable stars, and stellar parameters are included in Gaia's second data release. Gaia DR2 is a source of new knowledge in practically all fields of astrophysics and on average more than three new scientific publications based on the Gaia data appear every day. In this talk a status report of the Gaia mission will be given and an outlook into the future data releases.

Primary author(s): JORDAN, Stefan (Astronomisches Rechen-Institut, Universität Heidelberg)

The Athena X-ray Observatory

Athena (Advanced Telescope for High ENergy Astrophysics) is the X-ray observatory mission selected by ESA, within its Cosmic Vision program, to address the Hot and Energetic Universe scientific theme. It is the second L(large)-class mission within that program and is due for launch in early 2030s. Athena will study how hot baryons assemble into groups and clusters of galaxies, determine their chemical enrichment across cosmic time, measure their mechanical energy and characterize the missing baryons which are expected to reside in intergalactic filamentary structures. At the same time, it will study the physics of accretion into compact objects, find the earliest accreting supermassive black holes and trace their growth even when in very obscured environment, and show how they influence the evolution of galaxies and clusters through feedback processes. Athena will also have a fast target of opportunity observational capability, enabling studies and usage of GRBs and other transient phenomena. As an observatory, Athena will offer vital information on high-energy phenomena on all classes of astrophysical objects, from solar system bodies to the most distant objects known. The satellite will consist of a single large-aperture grazing-incidence X-ray telescope, utilizing a novel technology (High-performance Si pore optics), with 12m focal length and 5 arcsec HEW on-axis angular resolution. The focal plane contains two instruments. One is the Wide Field Imager (WFI) providing sensitive wide field imaging and spectroscopy and high count-rate capability. The other one is the X-ray Integral Field Unit (X-IFU) delivering spatially resolved high-resolution X-ray spectroscopy over a limited field of view. I will present an overview of the anticipated Athena science and describe the status of the developments of the instruments and optics.

Primary author(s): RAU, Arne (MPE)

Exploring the deep and variable X-ray sky: The source catalogue from overlapping XMM-Newton observations

Within the 20 years since its launch, Europe's space telescope XMM-Newton has performed 13,000 observations of the X-ray sky so far, covering more than 1,100 square degrees in total. About one third of this area was visited several times. The XMM-Newton Survey Science Centre consortium (SSC) generates source catalogues from all usable observations. In 2018, we have published for the first time a catalogue from simultaneous source detection in a selection of overlapping observations. It is based on a new standardised procedure for multiply observed sky areas and exploits the longer effective exposure time of the combined observations, which allows for additional detections of faint sources and more precise determination of the source parameters. The parameters include position, fluxes, hardness ratios, extent, and inter-observation variability. We will celebrate the 20th anniversary of XMM-Newton with new, fully re-processed source catalogues. The next catalogue of repeatedly observed X-ray sources will be based on about 7,000 individual observations. It will serve as a large data base for X-ray studies, for detection of so far un-known long-term variability, and for cross-identifications with multi-wavelength catalogues.

Primary author(s): TRAULSEN, Iris (AIP), SCHWOPE, Axel D. (AIP); LAMER, Georg (AIP); ON BEHALF OF THE XMM-NEWTON SURVEY SCIENCE CENTRE CONSORTIUM

High resolution infrared observations towards late-type stars - Opportunities and Challenges

New instruments such as CRIRES/VLT, TEXES/Gemini North or EXES/SOFIA enable high-resolution (R $>$ 80 000) observations of inter- and circumstellar molecules. The combination of these high-resolution spectrometers with large dish telescopes or extraordinary locations, which are possible via the EXES/SOFIA instrument at a height of 12 km, opens up unprecedented possibilities for infrared astronomy. Gas phase molecules can be clearly identified by their line spectra and used as probes for local physical and chemical conditions such as density, temperature, radiation field and chemical composition. However, in contrast to conventional radio and mm observations, the atmosphere is not completely transparent at IR wavelengths and often hinders an undisturbed view into the infrared sky. Using the latest TEXES/IRTF observations of the late-type stars VY Canis Majoris and o Ceti (Mira), the potentials and challenges of high-resolution IR observations are discussed.

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A new advent for balloon-borne astronomy?

With the availability of long flight durations of several weeks to months and increased reliability, balloon-borne astronomical platforms have become increasingly popular again in Europe and worldwide over the last 10 to 15 years. The continuously costly access to space for larger payloads combined with the needs for larger telescopes and specialised, up-to-date instruments makes the comparatively flexible and effort-efficient balloon platforms attractive options to complement other observational capabilities.
This talk will present details on the observational and operational environment of astronomical stratospheric balloons missions, mention some recent highlights, and outline the idea of a European Stratospheric Balloon Observatory.

Primary author(s): MAIER, Philipp (University of Stuttgart)

Sunrise-3: a close-up view of the Sun from a stratospheric balloon

The balloon-borne solar observatory SUNRISE is currently being prepared for its third scientific flight in 2021. A close-up view of the processes in the solar atmosphere will be provided by a completely new suite of instruments attached to the 1-meter solar telescope. Two slit-based spectro-polarimeters for the near ultra-violet (SUSI / MPS) and the near-infrared (SCIP / NAOJ), and the imaging spectro-polarimeter IMaX+ will allow for detailed measurements of the atmospheric parameters from the deep photosphere up to chromospheric heights at a spatial resolution of 70 km with unprecedented height resolution. In addition, the observations from the stratosphere bear a big discovery potential for solar polarimetry in the UV spectral range from 300 to 400 nm, a wavelength range difficult to access for ground-based solar telescopes.
In this presentation we will highlight some major results of the previous two SUNRISE flights, present an overview of the new Sunrise-3 instrumentation and the status of the project, and provide an outlook to the expected scientific return.
SUNRISE 3 is a joint project of the German Max-Planck-Institut für Sonnensystemforschung together with the Spanish SUNRISE consortium, the Johns Hopkins University Applied Physics Laboratory, USA, the German Kiepenheuer Institut für Sonnenphysik, the National Astronomical Observatory of Japan and the Japan Aerospace eXploration Agency.

Primary author(s): LAGG, Andreas (MPS); SOLANKI, Sami K. (MPS), and the Sunrise-3 Consortium (including KIS, IAA, NAOJ, JHUAPL)

Hard X-ray polarimetry from a stabilised balloon-borne platform

Advances in the field of X-ray astrophysics are currently driven by spectroscopy, imaging and timing studies. Many astrophysical X-ray sources are dominated by non-thermal emission with radiation transferred in highly asymmetric systems. A measurement of the linear polarisation of the emitted radiation therefore constitutes a key, but currently underused, observable and diagnostic for sources which cannot be spatially resolved. PoGO+ is a balloon-borne hard X-ray polarimeter operating in the 20 - 200 keV energy band. PoGO+ was launched from the Esrange Space Center in July 2016 to observe the Crab pulsar and black-hole binary Cygnus X-1 during a week-long flight to Canada. PoGO+ technology, the mission design, and results from the 2016 flight will be discussed.

Primary author(s): PEARCE, Mark (KTH Royal Institute of Technology)

Ultraviolet Detector Development and Application

Astronomical observations in the ultraviolet (UV, below 300 nm) are not possible from ground since the ozone layer of Earth's atmosphere is absorbing almost all incoming radiation. UV observations are therefore done either from space, sounding rockets or stratospheric balloons, which always goes along with special requirements for the instrumentation.
At the Institute for Astronomy and Astrophysics (IAAT) we have developed an UV detector, suitable for space and balloon missions. It is a single photon-counting device based on the microchannel plate (MCP) technology. The goal is high quantum efficiency as well as high spatial resolution while maintaining low power consumption and low weight. The currently developed version of the detector will be used on the STUDIO instrument (Stratospheric Ultraviolet Demonstrator of an Imaging Observatory) for ESBO *DS* (European Stratospheric Balloon Observatory *Design Study*). We will present details of our detector and how we match the specific requirements for the upcoming balloon mission.

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Cosmic Dust and Spectral Line Polarization as Analytical Tools

Room 9.12

Content: In the past years, great efforts were undertaken to measure the Stokes parameters of continuum and spectral line emission across a variety of cosmic environments. This splinter meeting is motivated by the arrival of polarimetry data from SOFIA and other observatories, operating from optical to radio wavelengths and including interferometers. We intend to offer an opportunity to present recent, exciting data and simulations as well as to discuss open questions and pending tests.

We invite contributions from various fields, out of which we suggest the following topics (the list is not exhaustive):

- For the first time, it is possible to obtain the spectral energy distribution of dust polarization, thanks to HAWC+ and other recently commissioned polarimeter cameras. Are we ready to use it as an analytical tool, e.g., for magnetic field tomography? If so, what is the contribution of Zeeman measurements?
- How sensitive is dust polarization to magnetic field structure? How can polarized emission be used, by itself or in combination with stellar polarimetry data, to probe grain alignment efficiency in molecular clouds? What is the role of alternative alignment processes?
- What is the dynamical role of magnetic fields in the formation of high-mass stars?
- What is the role of magnetic fields in the formation of molecular clouds out of cold, neutral matter? Is there a difference between the Galaxy and, e.g., the low metallicity environment of the Magellanic clouds?
- What is the link between filamentary molecular cloud structures, the striations feeding them, and the stellar proto-clusters forming inside dense cores?
- Recent observations of protoplanetary disks forming around low-mass stars have revealed a wealth of details. What is the role of the magnetic field in the angular momentum budget of the disks, at various evolutionary stages?
- What is the role of magnetic fields in late stages of stellar evolution? Are they an important agent for shaping planetary nebulae?

Radiative torque alignment of dust grains

Dust induced polarization is an efficient probe of the interstellar magnetic field. The combination of short wavelength dichroic extinction polarimetry with far-infrared/sub-mm wave emission observations, using modern instruments, allows us to measure the polarization from diffuse gas to star forming cores. With our improved understanding of the physics of grain alignment we can now better interpret the observations and evaluate the importance of the magnetic field. Radiative Alignment Torque (RAT) grain-alignment has been observationally confirmed, but some aspects and details are still being clarified. The quantitative theoretical frame work provided by RAT theory also allows long standing questions about the interstellar environment and dust characteristics to be addressed anew - including dust composition and structure. I will review the basics of RAT alignment and its observational support and discuss some of the open questions of dust induced polarization.

Primary author(s): ANDERSSON, B-G

Unveiling the magnetic field properties of a Class 0 protostar with SOFIA/HAWC+

Magnetic fields are believed to play a crucial role in the star formation process. While filamentary structures are thought to be formed from magnetically driven cloud contraction, at core scales magnetic fields can provide a source of support against the collapse. In this context, single-dish observations are of great importance to understand the role of magnetic fields at core scales. We have used the SOFIA/HAWC+ camera at 1.4THz to perform polarimetric observations of the Class 0 object IRAS 15398-3359 (IRAS15398 hereafter), embedded in the Lupus I cloud. Previous optical polarimetric observations revealed that Lupus I is threaded by an ordered magnetic field perpendicular to its long axis, suggesting that IRAS15398 evolved in a highly magnetized environment. Indeed, our SOFIA results unveil an ordered magnetic field aligned with the large scale cloud field and with the bipolar outflow powered by IRAS15398. We report the hourglass shape of the field lines predicted by the magnetically-driven collapse theory, the first detection in the low-mass regime performed with SOFIA. Using the structure function analysis, combined with the modified Chandrasekhar-Fermi method, we estimate a turbulent-to-uniform ratio for the magnetic field of $B_t / B_0 = 0.075 \pm 0.08$, and a field strength on the plane-of-sky of $B_{pos} \approx 480\mu G$. Furthermore, we derive a mass-to-flux ratio of $\lambda \approx 0.15$, significantly lower than its critical value ($\lambda = 1$). Our results suggest that IRAS15398 evolved in an highly magnetised environment, and that the core inherited the strong and ordered magnetic field from the parental cloud. This scenario is supported also by the lack of a large protoplanetary disk, as revealed by interferometric data, which can imply that magnetic breaking is efficient. Future polarimetric observations with ALMA will allow us to investigate wether this strong and uniform magnetic field is preserved at disk/envelope scales.

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Line polarization to solve the polarizing puzzle in dusty disks

From a theoretical point-of-view, magnetic fields are crucial to the evolution of planet-forming disks. However, profound observational constraints are pending. Presently, the number of cutting-edge polarization observations presenting inconclusive data increases continuously. In very recent years, polarization at mm-wavelengths, the classical tracer of magnetic fields, emerged as highly ambiguous, and the pressing demand for comprehensive tools to analyze these new observations is growing. I will present a potential solution to this dusty ambiguity, linearly polarized gas emission and the first results for disks.

Primary author(s): BERTRANG, Gesa H.-M. (MPIA)

The far-infrared polarization spectrum of Rho Ophiuchi A from HAWC+/SOFIA observations

In this work, we report polarimetric observations of the densest portions of the Rho Ophiuchi molecular complex (known as Rho Oph A) from HAWC+/SOFIA. Rho Oph A was mapped with HAWC+ bands C (89 microns) and D (154 microns). This allowed us to examine the slope of the polarized emission spectrum by defining the quantity $R_{DC} = p(D)/p(C)$, where p(C) and p(D) represent polarization degrees in bands C and D, respectively. We notice a clear correlation between R_{DC} and the molecular hydrogen column density across the cloud. A positive slope dominates the lower density and well illuminated portions of the cloud (which is warmed up by the Oph S1 massive star), whereas a transition to a negative slope is observed at the denser and less evenly illuminated cloud core. We interpret the trends as due to a combination between: (1) Warm grains at the cloud outskirts, which are efficiently aligned from the abundant exposure to radiation from Oph S1, as proposed from the radiative torques theory; and (2) Cold grains deep in the cloud core which are poorly aligned due to shielding from external radiation. To test this assumption, we developed a very simple toy model using a spherically symmetric cloud core based on Herschel data, and verified that the calculated variation of R_{DC} is consistent with the observations. This result introduces a new method that can be used to probe the grain alignment efficiency in molecular clouds, based on the analysis of the far-infrared polarization spectrum.

Primary author(s): SANTOS, Fabio (MPIA)
Co-author(s): SCIENCE TEAM, HAWC+

SOFIA/HAWC+ polarimetric observations of the Bok globule B335

Due to their well-defined shape and mostly isolated locations, Bok globules are suitable objects to study star formation. Polarimetric observations of Bok globules at submm/mm wavelengths revealed a unique feature: The polarization degree decreases towards their dense centers ("polarization holes"; Rao et al., 1998; Vallée et al., 2003; Wolf et al., 2003). Various explanations for this phenomenon exist. One of them is based on the optical depth structure. Here, due to the impact of dichroic absorption of aligned grains in the dense, innermost regions, counteracting the polarized emission of these grains, the polarization degree decreases (Brauer et al., 2016). To investigate this influence of the optical depth, we obtained a spatially resolved polarization map of the prototypical Bok globule B335 with SOFIA/HAWC+ at a wavelength of 214 micron. In this context, we combined these data with smaller and larger-scale polarization maps of this object at submm/mm wavelengths. Furthermore, applying the 3D Monte-Carlo radiative transfer code POLARIS (Reissl et al., 2016), we develop a model for the density, temperature and magnetic field structure as well as for the dust properties of this globule.

Bibliography:

Brauer, R., S. Wolf, and S. Reissl (2016). Astronomy & Astrophysics 588, A129

Rao, R., R. M. Crutcher, R. L. Plambeck, and M. C. H. Wright (1998). The Astrophysical Journal Letters 502, L75

Reissl, S., S. Wolf, and R. Brauer (2016). Astronomy & Astrophysics 593, A87

Vallée, J. P., J. S. Greaves, and J. D. Fiege (2003). The Astrophysical Journal 588, 910

Wolf, S., R. Launhardt, and T. Henning (2003). The Astrophysical Journal 592.1, 233

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The impact of grain alignment on polarized dust emission

Magnetic fields are the key ingredient in many astrophysical processes. Observations of dust grains aligned with the magnetic field direction are a common technique to infer the magnetic field morphology. Driven by sub-mm instruments, e.g. SOPHIA / HAWC+, in this talk I focus on a specific astrophysical problem that currently beg re-evaluation: Does grain alignment physics cause a detectable imprint on the observable polarization signal? I will present results from my radiative transfer (RT) code POLARIS, which covers multiple facets of the radiative transfer (RT) problem such as dust heating and the best of our current knowledge of non-spherical grain alignment physics. Based on this, I derive dust emission and polarization maps of a large-scale MHD simulation of the diffuse interstellar medium. Here, I focus mostly on radiative torques (RAT), the most promising theory of grain alignment. I will show that this type of RT post-processing does reproduce the characteristic polarization pattern and statistics of the orientation angles known from observations. Different alignment scenarios and models of the radiation field show little effect on the emerging polarization signal. Hence, the fingerprint of RATs alignment cannot be detected with large-scale observations. In combination with observations, this analysis sheds new light on the classic problems of grain alignment physics and most important improves our understanding of dust polarization pattern and subsequently the underlying magnetic field morphology.

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Satellite Events

Several additional events are taking place during and around the conference. Here is a list of these events with additional information.

AstroFrauenNetzwerk Get-together

The Astro-Frauen Meeting will take place on Monday afternoon, starting at 16:00 in room 9.11.

PhD Students Meeting

PhD students Meeting will take place on Monday afternoon, starting at 13:00 in room 9.11.

AG Members Meeting

The 92nd members meeting of German Astronomical Society will take place on Tuesday afternoon, starting at 17:00 in lecture hall 47.02. This is a closed session for members of the AG only.

Conference Dinner

The conference dinner is on Wendesday evening, starting at 19:15 at the Marché Tierpark Wilhelma Stuttgart, Neckartalstraße, 70376 Stuttgart. Please, use the main entrance of Wilhelma. Keep in mind that it will be open only until shortly after 8 p.m. - late arrival is not possible.
A registration confirmation for the conference dinner is mandatory to participate - please show the voucher you received at registration desk at the Wilhelma main entrance.

The best way to get to Wilhelma (starting at University) is one of the following connections:

18:29	**S1** (to *Plochingen*, Platform 2) - leave the train at "Stadtmitte" and follow this sign **U**. Take:
18:42	**U14** (to *Mühlhausen*) - leave the train at "Wilhelma" and cross the tracks. Go to the big pavilion, the main entrance is behind.

18:39 **S2** (to *Schorndorf*, Platform 2) - leave the train at ”Stadtmitte” and follow this sign . Take:
18:52 **U14** (to *Mühlhausen*) - leave the train at ”Wilhelma” and cross the tracks. Go to the big pavilion, the main entrance is behind.

18:49 **S3** (to *Backnang*, Platform 2) - leave the train at ”Stadtmitte” and follow this sign . Take:
19:02 **U14** (to *Mühlhausen*) - leave the train at ”Wilhelma” and cross the tracks. Go to the big pavilion, the main entrance is behind.

Each specific connection runs every 30 min. The latest possible connection to arrive at Wilhelma before the entrance will close runs at 19:29 from University (Arrival at 19:55). Please keep in mind that you have only got 4 min to change trains at ”Stadtmitte” and the S-Bahn might be not on time!

Public Talk

The public talk will take place Thursday evening, starting at 20:00 in Hospitalhof, Buechsenstr. 33, 70174 Stuttgart. The talk will be presented by Harold Yorke (USRA) and Yoko Okada (Universität zu Köln). Reinhold Ewald (University of Stuttgart, ESA astronaut) will be chair of the talk.

To reach Hospitalhof best take **S1** (to Plochingen), **S2** (to Schorndorf) or **S3** (to Backnang) from platform 2 at the University. Leave the train at ”Stadtmitte” and follow the signs to ”Büchsenstraße”. The way is marked on the map on the next page - the tracks of the S-Bahn are marked in green, please follow the orange line by foot. You will leave the station approximately between number 20 and 22 on the map.

Trains are running from University at 19:04, 19:09, 19:14, ..., 19:34. You will need approximately 16min to the Hospitalhof.

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Posters

Poster Sessions will be held during all coffee breaks. The following list provides the title of the session and the name of the first author.

From Protoplanetary Disks to Exoplanets

- SCHOBERT, Benjamin - The impact of accretion heating and thermal conduction on the dead zone of protoplanetary disks
- LÖHNERT, Lucas - Mixing Length Estimates for Gravitational Turbulence
- SMIRNOV-PINCHUKOV, Grigorii - Chemistry in Disks: modeling the substructure of circumstellar disks

OGLE-ing the Variable Sky

- IWANEK, Patryk - 12 660 spotted stars towards the OGLE Galactic bulge fields
- WRONA, Marcin - Overview of the OGLE Collection of Variable Stars

Solar Activity

- VALLIAPPAN, Senthamizh Pavai - Historical sunspot observations constraining the dynamo behind the solar cycle

Star Formation and Stellar Feedback

- ANTONELLINI, Stefano - The dawn of Complex Organic Molecules: the case of L1544
- STANKE, Thomas - How do stars form around Super Star Clusters? A survey for massive cloud cores around the NGC 3603 starburst cluster

SOFIA Measurements of Nearby Galaxies and the Central Molecular Zone of the Milky Way

- BECK, Andre - SOFIA/FIFI-LS Observations of the Starburst Galaxy NGC 253
- LATZKO, Serina T - Observations of the Starburst Galaxy M82 with SOFIA/FIFI-LS

Computational Astrophysics

- BLANK, Marvin - Say NIHAO to Black Holes
- STEINWANDEL, Ulrich - On the importance of the compact wave solution in magnetohydrodynamical shocks
- STEINWANDEL, Ulrich - Resonant Drag Instabilities: Consequences for the atmospheres of AGB-stars

Future Astronomical Opportunities in Stratosphere and Space

- TITZ-WEIDER, Ruth - CHEOPS
- TITZ-WEIDER, Ruth - PLATO
- HUGHES, Annie - PILOT: First Results and Inflight Performance
- PAHLER, Andreas - STUDIO: A first step towards a stratospheric balloon observatory
- HUGHES, Annie - COPILOT: C+ Observations of the ISM with PILOT

New Challenges in Stellar Spectroscopy

- PAWAR, T. - Variability in the light curves of hot subdwarfs

General

- MAKAN, Kirill - Probing HeII reionization at $z > 3.4$ with resolved HeII Lyman-Alpha forest spectra.
- RAZA, Belal - Improving CARMENES Radial Velocity Estimations
- KÖNIG, Lorenzo - Eclipsing Binaries in the Orion OB1 Association
- HØG, Erik - Gaia Successor with International Participation
- TEMI, Pasquale - SOFIA at Full Operation Capability: Technical Performance

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Zinnecker, Hans, Univ. of Stuttgart (guest)

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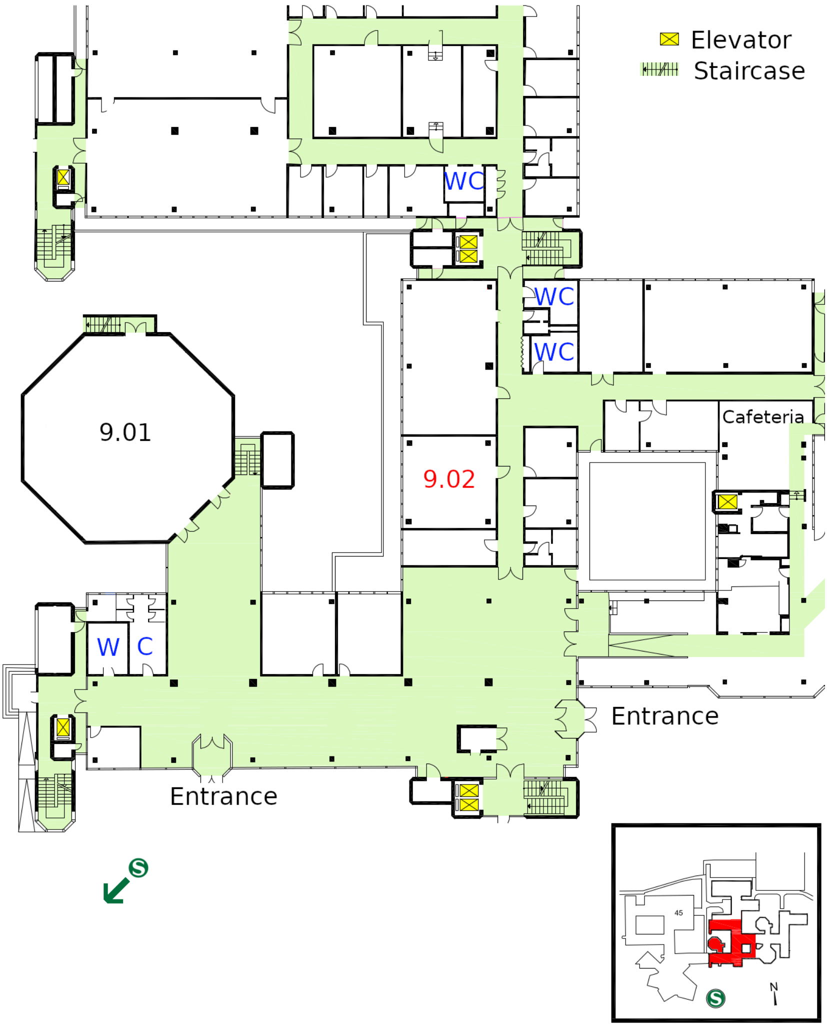
Conference Venue (Maps)

Maps of buildings and campus

Building 9: Ground Floor

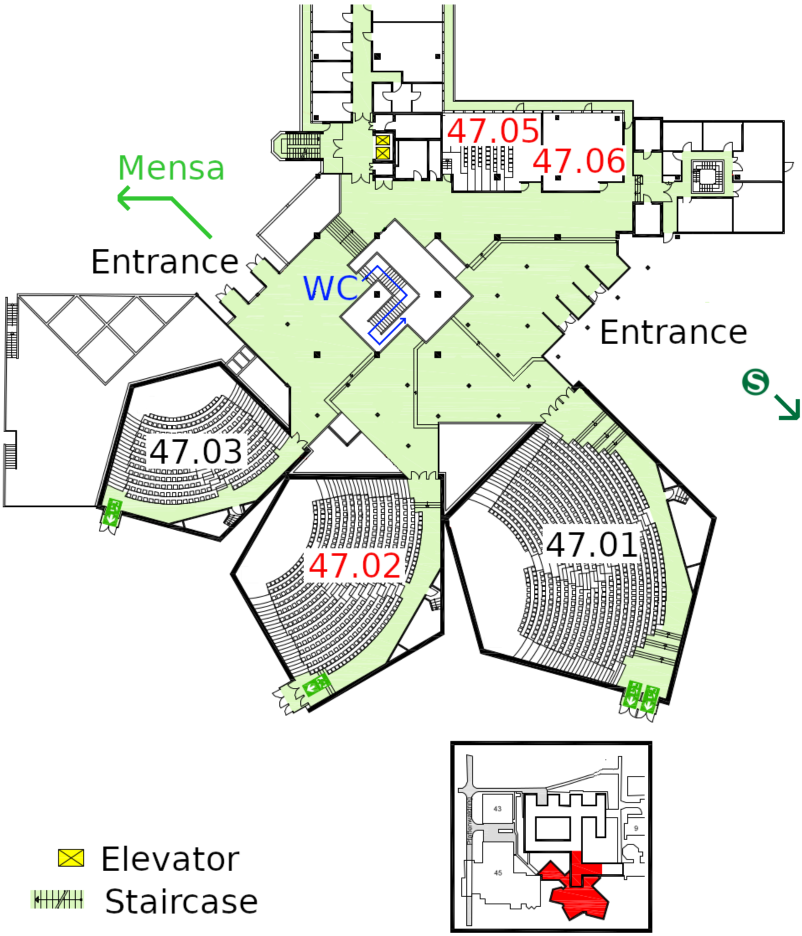


Building 9: Floors (x) 1 to 3

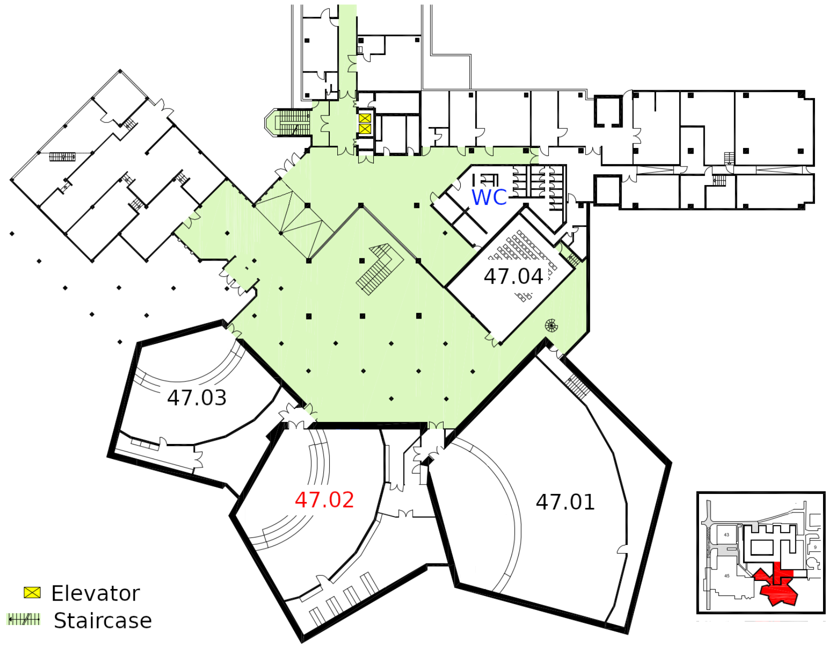
Building 9: 4th floor

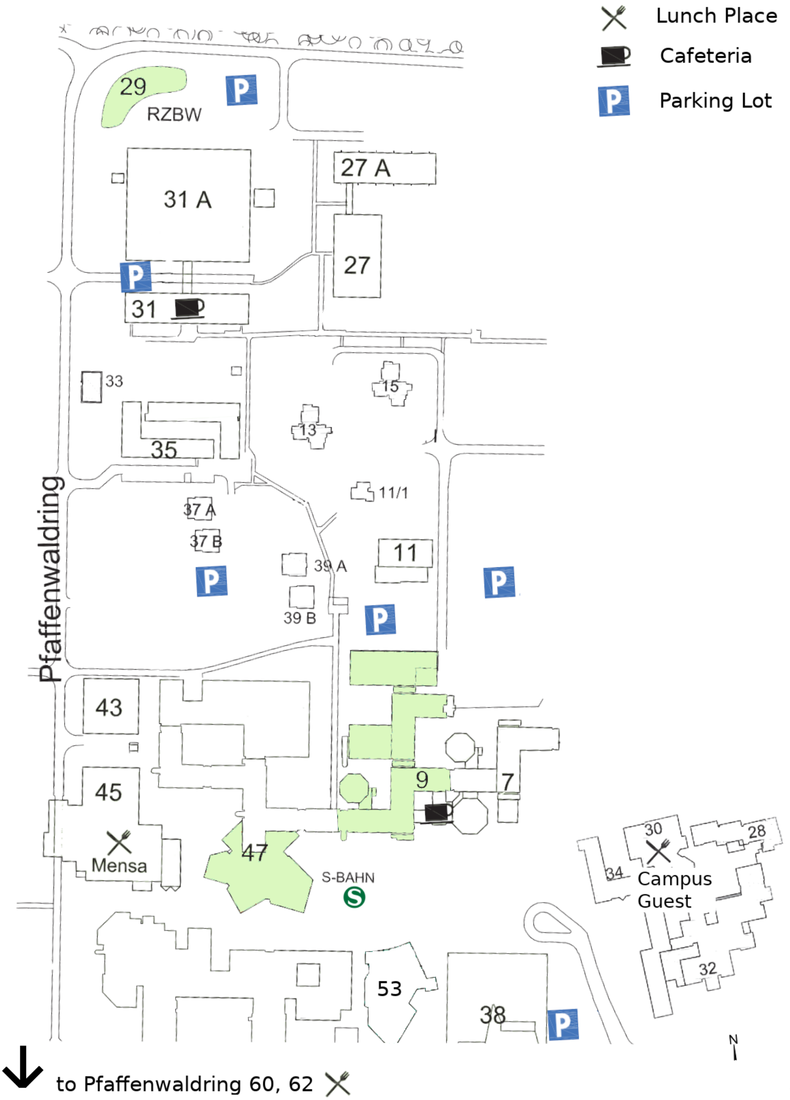
Building 29: Ground floor

Building 47: Ground floor



Building 47: Basement





Lunch Place
Cafeteria
Parking Lot
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Code of Conduct

As an association for scientists in the fields of astronomy and astrophysics as well as friends of astronomy, the German Astronomical Society (AG) serves to support science, research and the exchange of scientific ideas and knowledge, in accordance with its statutes. In accordance with the principle of equal participation, all members should be free to take part in scientific exchange regardless of ethnicity, gender, religion, worldview, disability, age or sexual identity. No member should be disadvantaged, feel they are in danger, or be subject to harassment or repression because of these reasons or others.

The members of the German Astronomical Society are obliged to conduct themselves respectfully and professionally at all times whilst working with the AG governing bodies (the general assembly, executive committee and the Council of German Observatories); in working groups and committees; as well as at AG events. In particular, participants of the AG annual meetings, including any scientific and social activities associated with the meetings, are obliged to abide by these rules.

The term harassment is defined as derogatory or offensive statements, sexualised representations, deliberate intimidation, stalking, persecution, unwanted photography, filming or recording, repeated disturbance of presentations and other events, unwanted bodily contact and unwanted sexual attention.

Members and conference participants who violate these rules, continue to behave inappropriately despite warnings or deliberately make false accusations about harassment will be disciplined accordingly by the event organiser or the AG executive committee.

Sanctions can range from a warning of suspension from the conference to a ban from future conferences and expulsion from the AG.

The organisers of AG meetings are obliged to adopt these principles as the code of conduct for their conference and to appoint contact persons who will follow up reports of discrimination. Alongside the conference organisers, the members of the AG executive committee can also be contacted about problems in relation to inappropriate behavior.

(Agreed at 89th members' assembly of the astronomical society in Bochum 2016.)

Notes on Data Protection

The personal data that are processed and saved at DSI are deleted in accordance with Art. 17 & 18 DSGVO or are limited in how they are processed. The saved data are deleted as soon as they are no longer needed for their original purpose, as long as there are no legal retention requirements for these data. If these data are not deleted because they are needed for legally permitted purposes, their use will be limited. The data are not used for any purposes other than those listed above.

Please note that the University of Stuttgart, the Astronomical Society and the press will take pictures for the purpose of publication during the conference and during the accompanying events planned by the University of Stuttgart.

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Sep, 16</th><th>Tuesday
Sep, 17</th><th>Wednesday
Sep, 18</th><th>Thursday
Sep, 19</th><th>Friday
Sep, 20</th><th>Time</th></tr>
<tr><td rowspan="8">Arbeitskreis
Astronomiegeschichte

Meeting AG Board</td><td>Opening and Award
Ceremony</td><td>Güsten</td><td>Schwarzschild ‘19
van Dishoeck</td><td>IAU 100 years</td><td>09:00</td></tr>
<tr><td rowspan="2">Schwarzschild ‘18
Udalski</td><td>Sasaki</td><td rowspan="2">Biermann Award ‘19
Starkenburg</td><td>Hildebrandt</td><td>09:30</td></tr>
<tr><td>Grinberg</td><td>PhD Award ‘18 Marchant</td><td>10:00</td></tr>
<tr><td colspan="4">Coffee Break & Poster Session</td><td>10:30</td></tr>
<tr><td>Software Award ‘18
Springel</td><td>Helmich</td><td>Zabludoff</td><td>Klinkner</td><td>11:00</td></tr>
<tr><td rowspan="2">Instrumentation Award ‘19
Høg, Lindegren, Perryman</td><td>Poppenhäger</td><td>PhD ‘19 Friedrich/Lichtenberg</td><td>Falcke</td><td>11:30</td></tr>
<tr><td>Barcons</td><td>Hasinger</td><td>Closing</td><td>12:00</td></tr>
<tr><td rowspan="3">Lunch Break</td><td rowspan="3">Conference Photo
Lunch Break</td><td rowspan="3">Lunch Break</td><td rowspan="3">Lunch Break</td><td>12:30</td></tr>
<tr><td rowspan="10">(cont.) Arbeitskreis
Astronomiegeschichte

RDS Meeting

PhD students Meeting
(13:00 – 16:00)

Astro-Frauen
(16:00 – 18:00)</td><td>13:00</td></tr>
<tr><td>13:30</td></tr>
<tr><td rowspan="2">Splinters</td><td rowspan="2">Splinters</td><td rowspan="2">Splinters</td><td rowspan="15"></td><td>14:00</td></tr>
<tr><td>14:30</td></tr>
<tr><td colspan="3" rowspan="2">Coffee Break & Poster Session (15:10 – 15:40)</td><td>15:00</td></tr>
<tr><td>15:30</td></tr>
<tr><td rowspan="4">Escience, Exoplantes,
OGLE, Solar Activity,
Spectroscopy,
Star Formation</td><td rowspan="4">EarlyMW, Escience,
Exoplanets, Maser,
SOFIA,
Spectroscopy</td><td rowspan="4">Computation,
EarlyMW, Education,
Future, Outreach,
Polarimetry</td><td>16:00</td></tr>
<tr><td>16:30</td></tr>
<tr><td>17:00</td></tr>
<tr><td>17:30</td></tr>
<tr><td></td><td rowspan="2">AG Members Meeting
Starting at 17:00</td><td rowspan="2"></td><td rowspan="4"></td><td>18:00</td></tr>
<tr><td rowspan="5">Welcome Reception</td><td>18:30</td></tr>
<tr><td rowspan="5"></td><td rowspan="5">Conference Dinner</td><td>19:00</td></tr>
<tr><td>19:30</td></tr>
<tr><td rowspan="3">Public Talk</td><td>20:00</td></tr>
<tr><td>20:30</td></tr>
<tr><td></td><td>21:00</td></tr>
</table>