ORIGIN AND FATE OF DUST IN OUR UNIVERSE

Göteborg 25-29 September 2023

UNIVERSITY OF GOTHENBURG

Knut and Alice Wallenberg Foundation

CHALMERS
UNIVERSITY OF TECHNOLOGY

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Welcome message

Dear Participants,

It is our great pleasure to welcome you to the Cosmic Dust conference, held from the 25th to the 29th of September in the beautiful city of Gothenburg, Sweden. This conference aims to serve as a multidisciplinary platform for researchers from around the world to exchange ideas, discover novel opportunities, and broaden their understanding of the fascinating subject of interstellar dust.

The conference is unique in its endeavor to bring together experts from theoretical, observational, and experimental backgrounds to create a dialogue about dust in various cosmic settings. We believe that each of these approaches offers invaluable insights.

As we delve into the intricacies of dust grains that permeate our universe, influence star formation, and contribute to complex chemical networks, it becomes clear that understanding these seemingly inconspicuous particles has implications far beyond what meets the eye—or even the telescope.

We have carefully curated a program that we believe caters to the diversity of topics and methodologies in the field of interstellar dust studies. We are delighted to have you in Gothenburg, a city that epitomises the blend of tradition and modernity, much like the interdisciplinary nature of our conference. While you're here, we encourage you to explore the city's rich history, dynamic culture, and natural beauty, and hope that your experience extends beyond the academic setting.

We want to extend special thanks to the Knut and Alice Wallenberg foundation as well as the Astrophysics and Plasma physics department (AoP) for the financial support. We also would like to thank all the volunteers who have worked behind the scenes to make this conference a reality. A special thank to Carlos Buchmann, the technician of the Venue, for taking care of the sounds and images during the conference as well as for designing the officiel poster of the conference. Your time, effort, and contributions have been invaluable.

We invite you to actively participate, collaborate, and contribute, making the most of the opportunities for learning and networking that these next few days will offer. Together, let us pave the way for new understandings, methodologies, and even the paradigms through which we understand interstellar dust.

Wishing you an inspiring and productive time at the conference.

Best regards,

The LOC of the Cosmic Dust conference

Practical information

General information

Currency, ATMs, and credit cards
The currency of Sweden is the swedish krona (SEK). SEK 1 corresponds to roughly EUR 0.084 or USD 0.09. In general, there is no need to withdraw any cash as virtually all places accept debit and credit cards. Should you anyway need to withdraw cash, there are ATMs at the airport and train station, and few can be found in the city as well.

We, however, strongly recommend using your credit/debit card only as we cannot guarantee that you will be able to use all the cash you bring with you.

Göteborg City Card
Göteborg City Card gives you free admission to lots of entertainment, sights, excursion, Liseberg amusement park (opposite the conference venue) and many museums. Parking and travel with trams, buses and boats are included. You will also get shopping booklets with discounts in selected stores. Maximise your stay in Gothenburg. The card is valid for 24, 48 or 72 h. More information: www.goteborg.com/citycard

Bike rental: Styr & Ställ
Gothenburg is a bike friendly city. Throughout the city you will find bike stands with rental bikes. For only SEK 75 you can rent a bicycle as often as you wish. The first half hour of each journey is always free, regardless of the number of journeys per day. Short time visitors can choose the 3-Day Pass, which can be purchased from any of the credit card terminals for just SEK 25. It is also included in the Göteborg City Card. More information: goteborg.com/en/styr-stall

Emergency contacts

Emergency number: 112

Healthcare advices: +46 771 1177 00

Police: +46 77 33 113 13

Thiebaut Schirmer (chair): +46 73 890 44 82

LOC mail address: cosmic-dust-sweden@sciencesconf.org

Public transport

- is run by Västtrafik. Tickets cannot often be purchased on board on buses (mostly trams, by a bank card) and from the app you can also email the receipts.

- The recommended way of purchasing tickets is, therefore, through the mobile app (Västtrafik ToGo).

You can also buy tickets at vending machines inside trams, or at some kiosks (Pressbyrån). Note that cash payment is not possible, and a bank card (preferably a credit card) is required.

- Tickets are valid for 90 minutes in trams, buses, trains, ferries (zone of Gothenburg).

- If you need to book a taxi, it costs approximately SEK 500 to/from Landvetter Airport. Ask for a fixed price. The driver should have a taxi ID card clearly displayed in the vehicle. Service is included in the taximeter price; therefore, tipping is not expected. Avoid unlicensed taxis. We recommend Taxi Göteborg: +46 (0)31 650 00 or their website.

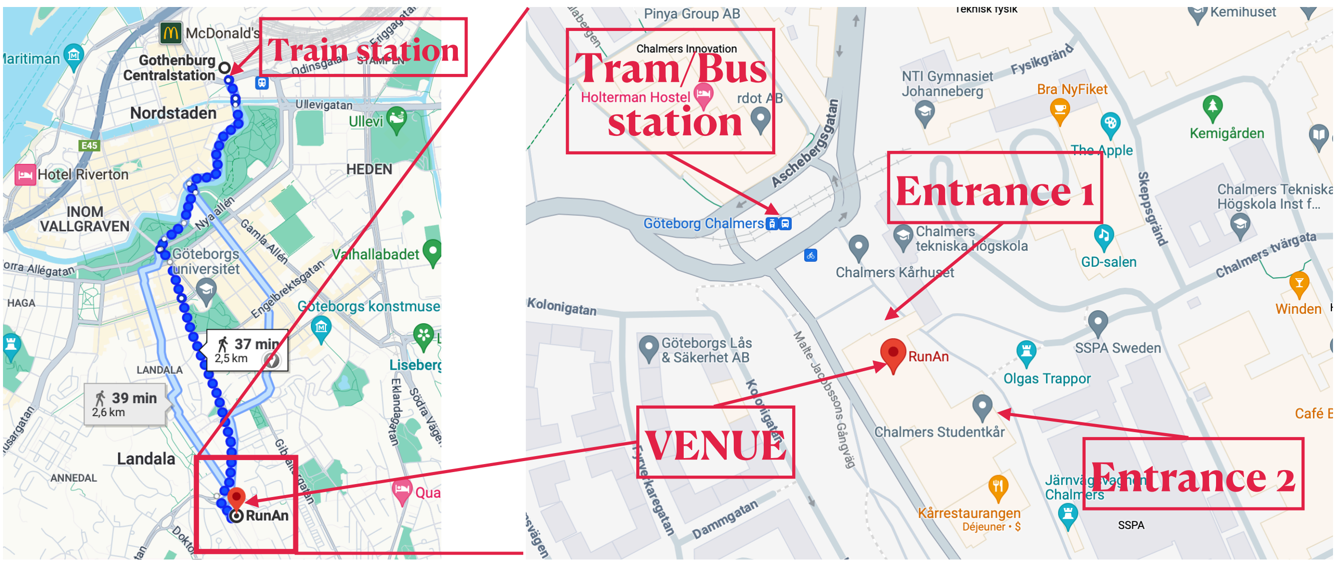
- Airport buses – Flygbussarna. It takes 30 minutes to travel between the "Landvetter" airport and the city center, the bus stop by central station is called "Nils Ericson Terminalen (Göteborg C)". Tickets costs SEK 119 single way and SEK 238 return, no cash is accepted on the bus only credit cards. For information and timetable, please visit www.flygbussarna.se

We recommend you to install the mobile app and connect your credit/debit card to it before your arrival to Gothenburg such as you just have to buy a ticket whenever you want.

How to get to the conference

The conference will take place in the room called RunAn (450 places, marked by the red pin on the image below) located in the Chalmers conference center, at the first floor.

Visiting address: Chalmers Konferens & Restauranger, Main entrance, Chalmers platsen 1, 412 58 Göteborg, Sweden.



Getting here by tram or by bus: The following buses are operating Chalmers: 16, 18, 19, 55, 58, 158 and 753. In addition, the trams 6, 7, 8 10 and 13 are operating Chalmers. Please visit Västtrafik for details.

By car: Please consult a map and/or GPS for the best alternatives for reaching your destination on campus by car.

Arriving in Gothenburg by train: Exit the train at the central station/the Nils Ericson terminal. Take bus 16, destination Högsbohöjd, from the stop Nordstan, just outside the terminal. From Drottningstorget, also just outside the central station, you can take tram 13, heading “Sahlgrenska”, to Chalmers. From Brunnsparken, approximately 500 meters from the central station, there are additional tram lines that will take you to Chalmers. Please visit Västtrafik for details.

If you travel via train from the south: your train will have final stop at Mölndal station, and it will not reach the central station. Buses to reach the Chalmers Johanneberg Campus will be available (20 to 25-minute ride), and also to reach the central station. Please visit Västtrafik for details or download the Västtrafik ToGo app to plan your journey.

Internet access

Eduroam is available on the entire campus including the conference venue at Kårhus (union building). In case you do not have an eduroam account, there is the possibility to connect as a guest to NOMAD, and we will have a list of usernames and passwords to connect locally. If you need one username and a password, we will provide you with one when you register.

Slack

This conference uses Slack as its main method of communication during the conference and to facilitate real-life socialising. Each day has a separate “Channel”, where we provide space to discuss the topics raised during the talks. Similarly, we prepared a poster channel as a convenient place to contact and address your questions to the poster presenters. Questions during the talks will be copied to Slack, and we encourage participants to continue their discussions with the audience as “Replies” to their talk. Please join us on Slack, and please say hi and introduce yourselves in our “Introductions” channel: link to the Slack

We remind our participants of our code of conduct, and note that unwelcome messages can be reported to any of the members of the LOC.

Figure 1: QR code towards the slack.

Social media

For those who are active on social media (X, Instagram, Facebook, etc.), feel free to use this hashtag if you post pictures associated to the conference: #CosmicDustSweden2023. We will gather the pictures after the conferences for the website.

Broadcasting

For those who were not able to come, here is the information to access the conference (for free) online. Please do not hesitate to share this link:

Join from a PC, Mac, iPad, iPhone or Android device:

Please click this URL to join. https://chalmers.zoom.us/j/68451951659
Passcode: 926471
Description: Within our collaboration on Cosmic Dust, funded by the Knut and Alice Wallenberg foundation, we are organizing a conference in Gothenburg (25th-29th September 2023) on dust, near and far.

Or One tap mobile:

+46850163827,,68451951659#,,,,*926471# Sweden
+46850500828,,68451951659#,,,,*926471# Sweden

Or join by phone:

Dial(for higher quality, dial a number based on your current location):
Sweden: +46 8 5016 3827 or +46 8 5050 0828 or +46 8 5050 0829 or +46 8 5052 0017 or +46 850 539 728 or +46 8 4468 2488
Webinar ID: 684 5195 1659
Passcode: 926471
International numbers available: https://chalmers.zoom.us/u/cctbCB7mIt

Or an H.323/SIP room system:

H.323: 109.105.112.236 or 109.105.112.235
Webinar ID: 684 5195 1659
Passcode: 926471

SIP: 68451951659@109.105.112.236 or 68451951659@109.105.112.235
Passcode: 926471

Gastronomy meets astronomy

The conference includes:

- Morning breaks (coffee, tea, fruits, rolls with fresh bread, vegetables and cheese[1]).
- Afternoon breaks (coffee, tea, fruits, pastries of the day).
- Monday and Tuesday evenings' mingles during the poster sessions with fresh juices and tapas:

[1] alternatives will be proposed for those who registered special allergies and/or diets

  - Sourdough bread and goat cheese crème.
  - Havgus cheese and rose hip marmelade.
  - Marinated olives and artichoke.
  - Thyme-glazed turnips and lemon crème.
  - Smoked pork shoulder.
  - Potato chips, smetana, dill and seaweed caviar.

- Wraps[2] on Wednesday at 12:45 pm and Friday at 1:00 pm. Note that for technical reasons, we in the end have two options instead of four. Those who chose the meat or fish wraps will have a chicken wrap instead (unless they specified they are vegetarian or that they have special allergies, in which case they will have a vegan wrap instead). Those who chose a vegetarian wrap will have a vegan wrap instead (as for the chicken wraps, we have informed the company in charge of the wraps about the allergies). A list with the choice you made can be consulted on the registration desk and each member of the LOC has the list so do not hesitate to ask us if you forgot what you had chosen.

  - Vegan - Pulled soy, hummus, carrots, kimchi, quinoa & romaine.
  - Chicken – Chili marinated chicken, soy-mayonnaise, cabbage, red onion & coriander.

Monday's, Tuesday's, and Thursday's lunches are not included. Some options for lunch in the vicinity of the conference venue:

Kårrestaurangen
Wijkanders
BOMBAY EXPRESS
Bov
Café Linsen
Waste
Kizuna Asian Eatery

Do not hesitate to use the Slack to discuss with other participants about possible places to eat.

[2]only for those who answer the poll sent two weeks before the conference.

Information for speakers and poster presenters

Speakers

The day before your talk

Invited talks are 30 minutes long (25+5 minutes for questions), and contributed talks are 15 minutes long (12+3 minutes for question).

We will use a Windows computer that will be connected to the video projector; thus, we need to copy your talks on this computer before the sessions. To do so, here is the procedure: we would like you to send us your presentation (.pdf format is recommended but it is also possible with a powerpoint format, at this address thisch@chalmers.se) the day before your presentation, by 9 pm. The name of your file must be firstname_lastname_daywhenyoutalk.pdf (thiebaut_schirmer_monday.pdf in my case if my talk were scheduled on Monday).

The day of your talk

During your talk, you will be equipped with a tie microphone and a wireless device. A technician will equip you with these devices before your session. Therefore:

- **if your talk is scheduled during the first session of the day**, please come in front of the stage 15 minutes before the session starts. Someone from the LOC and the technician will then take care of you and equip you with these devices.

- **if your talk is scheduled after a coffee break**, please come in front of the stage just after the end of the previous session (and therefore before going to the coffee break. In practice, if the coffee break is scheduled between 10 am and 10:45 am, please come in front of the stage at 10 am if your talk is scheduled during the session that starts at 10:45 am).

- **if your talk is scheduled just after lunch**, please come in front of the stage 10 minutes before the session starts. Someone from the LOC and the technician will then take care of you and equip you with these devices.

Poster presenters

General information

The poster format is A0 with vertical orientation (portrait). Posters will be available for viewing during the whole duration of the conference at the coffee-break area. You are free to hang your poster on the board with the corresponding number as soon as you register. Posters should be taken down by Friday lunch time at the latest.

We have two sessions dedicated to poster viewing and discussion on Monday and Tuesday evening. During these sessions, snacks will also be provided. On Monday and Tuesday there will be poster flash presentations which will take place in the conference room (RunAn).

Additionally, we will have a prize for the best poster(s) and a poster quiz which will be compiled based on questions submitted by the poster presenters. Everyone is welcome and encouraged to vote on the best posters and take part in the quiz!

First flash session - Monday, 25th September - 5 pm/5:30 pm

After a few-minute introduction of this flash session by members of the LOC, we will invite all the 12 members of this first flash session to wait in line close to the stage, following the order that is indicated below. Then, you will have one minute to advertise your poster with the help of the slide you sent us (for those who did not send the slide on time but who want to participate, we will create a simple slide with your name, institution and poster title).

After this flash presentation, we invite the following 12 speakers of this first flash session to stay close to their respective posters as we will encourage people to come and discuss with you.

Presenter	Title
Arya M Nair	Collision induced dissociation of water pyrene molecular clusters
Miora Andriantsaralaza	DEATHSTAR – Accurate mass-loss-rate estimates for AGB stars
Stefan van der Giessen	Disentangling galaxy and dust evolution mechanisms through chemical abundances
Joseph Nuth	Dust coagulation in oxygen-rich circumstellar outflows
Minju Lee	Dust content in a z$\sim$2 quiescent galaxy
Christina Konstantopoulou	Dust depletion of metals from from the Milky Way to z$\sim$6
Monica Relano	Dust grain size evolution in local galaxies as a key to understand galaxy evolution
Petia Yanchulova Merica-Jones	Dust properties and extinction curves in the magellanic clouds, M31, and M33
Pablo Rivière	Dust surface chemistry in the AB Aur protoplanetary disk: observations and models
Elvire De Beck	Dusty feedback from massive stars
Andreas Møller Slavensky	Generating candidates in global optimization algorithms using complementary energy landscapes

Thomas Vannieuwenhuyse	Paradigmatic examples for testing models of optical light polarization by spheroidal dust

Second flash session - Tuesday, 26th September - 4:30 pm/5 pm

After a few-minute introduction of this flash session by members of the LOC, we will invite all the 14 members of this first flash session to wait in line close to the stage, following the order that is indicated below. Then, you will have one minute to advertise your poster with the help of the slide you sent us (for those who did not send the slide on time but who want to participate, we will create a simple slide with your name, institution and poster title).

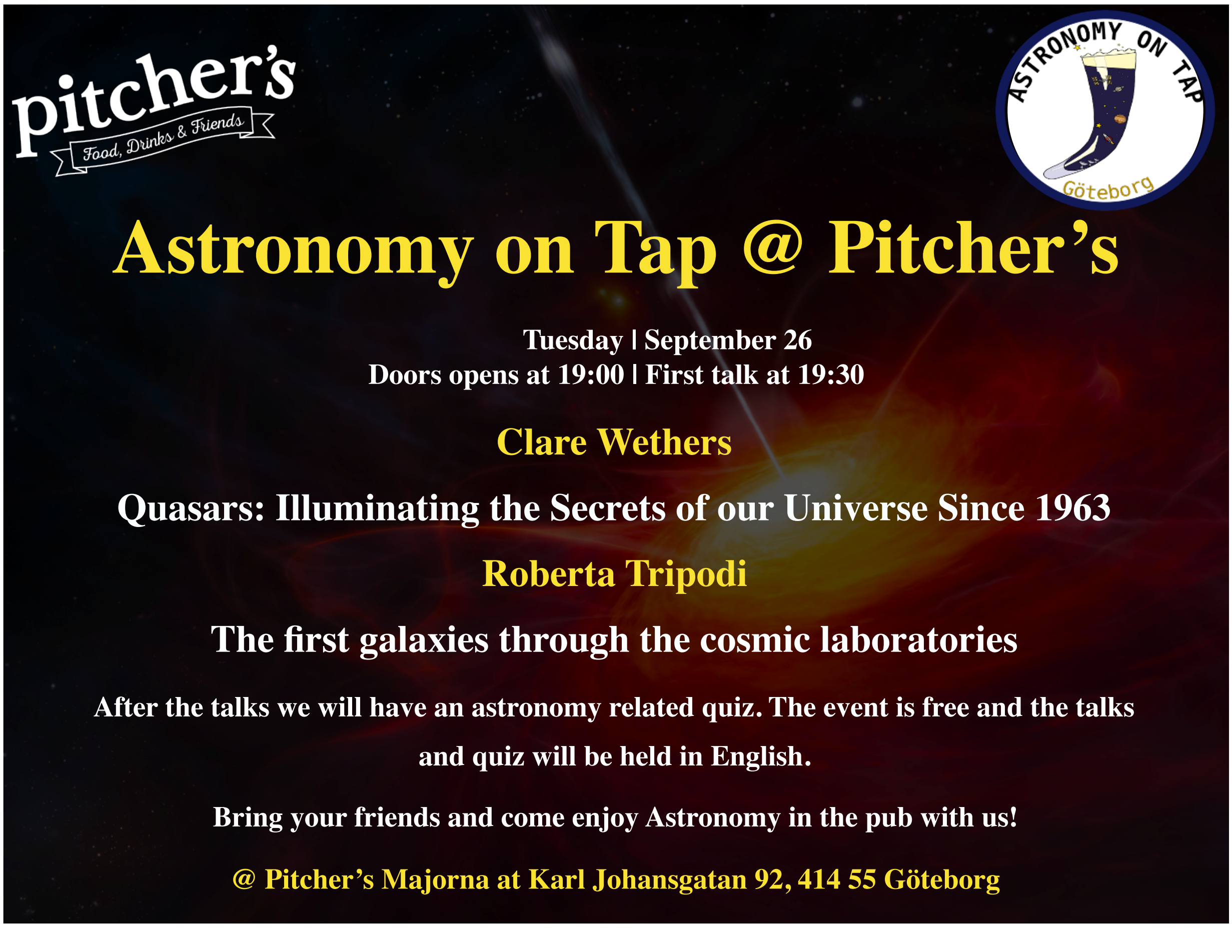
After this flash presentation, we invite the following 16 speakers of this first flash session to stay close to their respective posters as we will encourage people to come and discuss with you.

Presenter	Title
Jun Yang	High resolution spectra of the Galactic Binary Pulsar 4U 1907+09
Ilse De Looze	High-resolution view of the inner circumgalactic medium of NGC891
Karl Gordon	Interstellar dust extinction from the far-ultraviolet to the mid-infrared
Burcu Günay (Karl Gordon)	Mapping the interstellar dust and ice with JWST
Jihye Hwang	Magnetic field revealed by polarized dust emission in G28.34
Marco Palla	Modelling the dust cycle in local discs: unveiling the contribution of dust processes at kpc scales.
Tom Bakx	A Novel sub-mm Galaxy Emission Line Survey (ANGELS)
Ramón J. Peláez	Plasma generation and characterization of ‘dense’ and ‘fluffy’ hydrocarbon cosmic dust analogs
Gent Frederick	Project SUPERPIG
Joachim Wiegert	Radiative transfer through 3D models of dust clouds around AGB-stars
Szanna Zsíros	Serendipitous detection of the dusty Type IIL SN 1980K with JWST/MIRI
Giovanni Tedeschi Prades	Simulating dust dynamics in SPH and MFM hydrodynamical simulations
Nina Sanches Sartorio	Supernova shocks and dust destruction: what role does the environment play?
Emelie Siderud	The effect of dust opacities on winds of carbon-rich AGB stars

Maharana Siddharth	Development of the Integral-field Spectro-Polarimetry Mode for the 1.9m SAAO Spectrograph for study of ISM of nearby galaxies

Social activities

Astronomy on Tap



Astronomy on Tap is a public outreach initiative designed to bring astronomy and space science to the general audience in relaxed settings like bars and breweries. These events feature short, informal talks by experts in the field, along with interactive activities like trivia games and quizzes. Aimed at making science accessible and engaging, Astronomy on Tap offers attendees the opportunity to learn about the latest research and discoveries while enjoying a social, casual atmosphere.

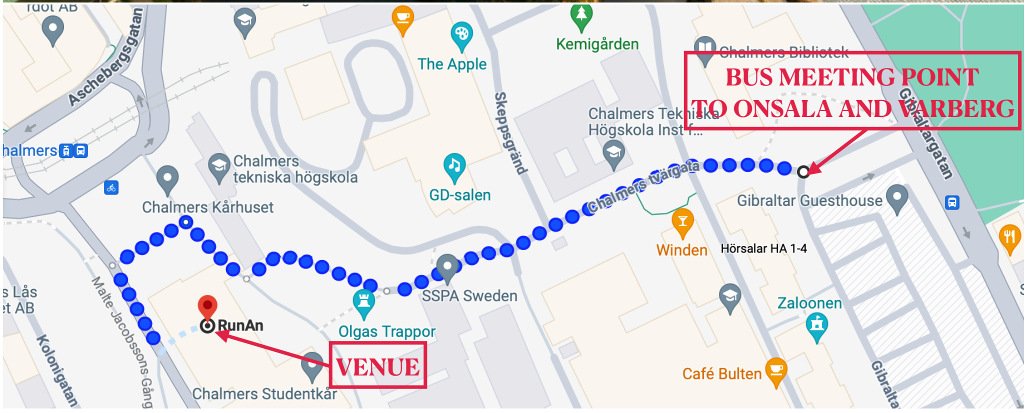
On Tuesday evening, we are excited to present two speakers to you:

- Clare Wethers, Post-doctoral researcher at Chalmers. Quasar: Illuminating the secrets of our Universe since 1963.

- Roberta Tripodi, PhD Student at University of Trieste. The first galaxies through the cosmic laboratories.

This event is free and will take place in Pitcher's Marjorna at Karl Johansgatan 92, 414 55 Göteborg. Some people from the LOC will probably directly go there from the Venue, after the Tuesday evening mingle. We will make an announcement to go there as a group for those who want.

Excursion to Varberg Fortress

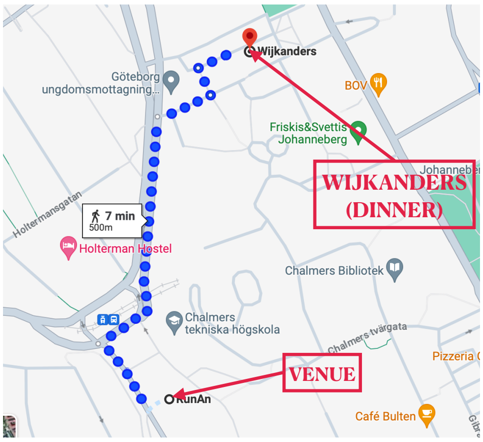


Buses will depart from Chalmers, nearby the library (see image above for the exact location and/or by clicking here), at 1.30 pm and take us to the small town of Varberg where we will visit the historic fortress Varberg fortress. After a 15-minute introduction of the fortress and museum, you can keep exploring the fortress many museum-exhibitions. You can learn about fascinating finds, such as the bog body called "the Bocksten man", found in a bog in 1936 dating back to medieval times, and learn about the history of the region, from ice sheets to beaches, and about the people who lived there. During our visit, you will be provided with fika, including coffee/tea and pastries (as the coffee place is small, we will make three groups which will enjoy the coffee break during three different time slots). You can also stroll around looking various landmarks. The bus will then leave at 5:30 pm for an arrival at Chalmers around 6:30 pm.

Schedule:

- **1:30 pm** Departure from Chalmers near the library.
- **2:30 pm** Arrival in Varberg.
- **2:30 pm–5:30 pm** Visit.
- **5:30 pm** Departure from Varberg.
- **6:30 pm** Arrival at Chalmers.

Social dinner at Wijkanders



We will have the conference dinner in Wijkanders, located on the Campus, a 5-minunte walk from the Venue. A list with the choice you made will be available at the dinner, and each member of the LOC has the list so do not hesitate to ask us if you forgot what you chose. During the dinner and when you will be served, please make sure you take the right meal.

Before the dinner, some canapés and bubbles (with or without alcohol) will be offered by the host institution. Only water is included in the dinner but you will have the opportunity to buy other beverages (wine, beer, juices, soda) during the dinner.

For those who already specified special diets (vegan, gluten free, lactose free, etc.), alternatives will be proposed.

Starters

Salmon / Trout roe / Sesame (*Salmon sashimi, ponzu, ginger emulsion, roasted cashew nuts, sesame seeds, black cabbage, kale chips & trout roe*)

OR

Beetroot / Avocado / Goat cheese (vegetarian) *(Beetroot steak, avocado, goat cheese cream, mache salad, salt roasted walnuts, beetroot chips & fried capers)*

Main course

Cod / Trout roe / Chervil *(Cod loin, champagne sauce, amandine potatoes, trout roe, chervil, chives & chive oil)*

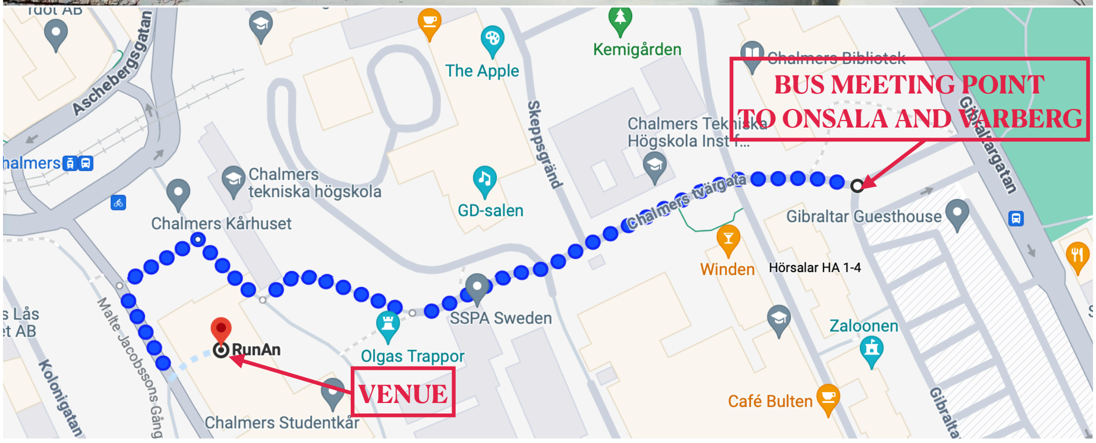
OR

Arancini / Burrata / Zucchini (vegetarian) *(Arancini, smoked paprika, baked cauliflower, grilled zucchini, burrata, cress & basil emulsion)*

Dessert

Apple / Ice cream / Buckwheat *(Apple pie with tosca topping, vanilla ice cream & fried buckwheat)*

Excursion to the Onsala Space Observatory



We organise an excursion to the Onsala Space Observatory on Friday afternoon, which is free for all participants. This includes fika and bus transfer to the observatory. Buses will depart from Chalmers, nearby the library (see the image above for the exact location and/or by clicking there), at 1 pm.

Schedule:

- **1 pm** Departure from Chalmers near the library.
- **1.50 pm** Arrival. Bus parks in the parking area and stays there.
- **2 pm** Brief presentation in the seminar room.
- **2.20 pm** Visit to 20-m telescope
- **2.35 pm** Walk to the visitor center.
- **2.50 pm** Visit to the visitor center. Fika served.
- **3.30 pm** Walk to the OTT, the FTIR spectrometer and the super tide gauge. Rerurn to the visitor center.
- **4.20 pm** End of visit. Bus departs from visitor center.
- **5.20 pm** Arrival at Chalmers.

About

Scientific Organising Committee (SOC)

Susanne Aalto - Chalmers University of Technology, Sweden
Ambra Nanni - Narodowe centrum badań jądrowych (NCBJ), Poland
Denis Burgarella - Laboratoire d'Astrophysique de Marseille (LAM), France
Benoit Commerçon - Ecole Normale Supérieure de Lyon (ENS Lyon), France
Herma Cuppen - Radboud University Nijmegen, Netherlands
Frederic Galliano - Commissariat à l'Energie Atomique (CEA Saclay), France
Karl Gordon - Space Telescope Science Institute (STScI), USA
Thiem Hoang - Korea Astronomy and Space Science Institute, Korea
Liv Hornekær - Aarhus University, Denmark
Kirsten Knudsen - Chalmers University of Technology, Sweden
Gunnar Nyman - University of Gothenburg, Sweden
Dimitra Rigopoulou - University of Oxford, UK
Thiebaut Schirmer (Co-chair) - Chalmers University of Technology, Sweden
Wouter Vlemmings (Chair) - Chalmers University of Technology, Sweden
Nathalie Ysard - Institut d'Astrophysique Spatiale (IAS Orsay), France

Local Organising Committee (LOC)

Thiebaut Schirmer (Chair) - Chalmers University of Technology
Wouter Vlemmings (Co-chair) - Chalmers University of Technology
Gunnar Nyman - University of Gothenburg
Susanne Aalto - Chalmers University of Technology
Kirsten Knudsen - Chalmers University of Technology
S. Rasoul Hashemi - University of Gothenburg
Duncan Bossion - University of Gothenburg
David Gobrecht - University of Gothenburg
Martina Šimsová - University of Gothenburg
Tom Bakx - Chalmers University of Technology
Gustav Olander - Chalmers University of Technology
Theo Khouri - Chalmers University of Technology
Matthias Maercker - Chalmers University of Technology

Timetable

CT: Contributed Talk, IT: Invited Talk.

Monday, 25th September, 2023

8am–10am	**Registration**		
10am–10:30am	**Coffee break**		
10:30am–11am	**Welcome**		
Chair: Karl Gordon			
11am–11:30am	IT	**Els Peeters** SETI Institute/Western University	PDRs4All: JWST's view of the Orion Bar
11:30am–11:45am	CT	**Monique Aller** Georgia Southern University	Dust grain properties in the gas-rich absorption systems of diverse galaxies at z<2
11:45am–12pm	CT	**Raphaël Meshaka** Observatoire de Paris-Meudon/IAS	The dust population in PDRs: impact on PDR structure and observable tracers
12pm–1:30pm	**Lunch**		
Chair: Gunnar Nyman			
1:30pm–2pm	IT	**Christine Joblin** Institut de recherche en astrophysique et planétologie	AstroPAHs: from laboratory experiments to observational diagnostics
2pm–2:15pm	CT	**Ismael Garcia-Bernete** University of Oxford	Polycyclic aromatic hydrocarbons and dust in star-forming regions and the vicinity of AGN: a JWST view
2:15pm–2:30pm	CT	**Zeyuan Tang** Center for Interstellar Catalysis, Aarhus University	A computational anharmonic IR database of nanosilicate clusters at astrochemically relevant temperatures
2:30pm–2:45pm	CT	**Karine Demyk** Institut de recherche en astrophysique et planétologie	Temperature-dependent optical properties of dust analogues for the interpretation of astronomical observations
2:45pm–3:30pm	**Coffee break**		
Chair: Kirsten Knudsen			
3:30pm–4pm	IT	**Ralf Siebenmorgen** European Southern Observatory	Dark dust
4pm–4:30pm	IT	**Tomoko Suzuki** Kavli IPMU	Dust content of galaxies at high redshift
4:30pm–4:45pm	CT	**Vladan Markov** Scuola Normale Superiore	Constraining the dust attenuation law in early galaxies with JWST
4:45pm–5pm	CT	**Roberta Tripodi** University of Trieste, INAF - Osservatorio Astronomico di Trieste	ALMA view on the dust properties of the HYPERION QSOs
5:00pm–5:30pm	**Poster flash session**		
5:30pm–8:00pm	**Poster session and mingle**		

Tuesday, 26th September, 2023

08:00–09:00	**Registration**		
Chair: Karl Gordon			
9:00am–9:30am	IT	**Anthony Jones** Institut d'Astrophysique Spatiale	Dust evolution between diffuse and dense environments — It's complicated
9:30am–9:45am	CT	**Meriem El Yajouri** Institut d'Astrophysique Spatiale	Dust evolution across the Orion bar: new insights from the JWST
9:45am–10:00am	CT	**Siddharth Maharana** South African Astronomical Observatory	PASIPHAE Survey: Large optical polarimetric sky survey for dust cloud and magnetic field tomography
10:00am–10:15am	CT	**Christian Kranhold** Astrophysical Institute and University Observatory, Friedrich-Schiller-University Jena	Small amounts of iron(II) sulphides can significantly affect the SEDs of circumstellar disks
10:15am–11:00am	**Coffee break**		
Chair: Gunnar Nyman			
11:00am–11:30am	IT	**Stefan Bromley** Institució Catalana de Recerca i Estudis Avançats [Barcelona], Universitat de Barcelona	Assessing the astronomical relevance of interstellar nanosilicate dust grains from IR spectra: theory, experiment and observation
11:30am–11:45am	CT	**Sascha Zeegers** ESA - ESTEC	Exploring the dust properties in the nearby diffuse interstellar medium with JWST
11:45am–12:00pm	CT	**Marjorie Decleir** Space Telescope Science Institute	Studying dust grain properties and growth by combining extinction and depletion measurements in the Milky Way
12pm–1:30pm	**Lunch**		
Chair: Dimitra Rigopoulou			
1:30pm–2pm	IT	**Anaëlle Maury** CEA/CNRS AIM, Université Paris Saclay	What do dust grains look like at the onset of the star and disk formation sequence?
2pm–2:15pm	CT	**Angelos Nersesian** Ghent University	Modelling the cold dust in nearby spiral galaxies with radiative transfer
2:15pm–2:30pm	CT	**Elisa Costantini** SRON Netherlands Institute for Space Research	The X-ray view of dust in the Milky Way
2:30pm–3:15pm	**Coffee break**		
Chair: Wouter Vlemmings			
3:15pm–3:45pm	IT	**Francois Menard** IPAG - Institut de Planetologie et d'Astrophysique de Grenoble	Dust properties from the Lab applied to young disks: 3D-printing and a Microwave Analogy Experiment
3:45pm–4pm	CT	**Marie Van de Sande** University of Leeds	The influence of a clumpy outflow and companion star on the surface composition of AGB dust

4pm–4:15pm	CT	**Dries Van De Putte** Space Telescope Science Institute	The far-UV-extinction-to-H2 correlation and insights from IR emission in photodissociation regions
4:15pm–4:30pm	CT	**Jun Yang** Massachusetts Institute of Technology	The Si K edge gas and dust optical depths toward the galactic bulge
4:30pm–4:45pm	CT	**Ekta Sharma** National Astronomical Observatories of China	Investigating the Magnetic Fields under stellar feedback using dust polarization
4:45pm–5pm	**Poster flash session**		
5pm–6:30pm	**Poster session and mingle**		
7pm–10pm	**Astronomy on Tap**		

Wednesday, 27th September, 2023

Chair: Elvire De Beck			
9:00am–9:30am	IT	**Martha Boyer** Space Telescope Science Institute	Dust in AGB stars
9:30am–9:45am	CT	**Matthias Maercker** Chalmers University of Technology	The contribution of dust from AGB stars to the ISM
9:45am–10:00am	CT	**Susanne Höfner** Department of Physics and Astronomy, Uppsala University	Stardust: From micro-physics to global dynamics
10:00am–10:15am	CT	**Leen Decin** Instituut voor Sterrenkunde, KU Leuven	Small pieces make up the big story
10:15am–10:30am	CT	**Lara Pantoni** IAS, Irfu/Dap	Dust millimetre emission in Nearby Galaxies with NIKA2/IRAM-30m: major challenges and latest results of the IMEGIN Large Program
10:30am–11:15am	**Coffee break**		
Chair: Liv Hornekær			
11:15am–11:45am	IT	**Cornelia Jäger** Laboratory Astrophysics Group, Max Planck Institute for Astronomy, Heidelberg	Laboratory studies on the production and processing of major cosmic dust components in laboratory
11:45am–12:15pm	IT	**Ilse De Looze** Department of physics and astronomy, Ghent University	Supernova dust formation: a high-resolution view with JWST
12:15pm–12:30pm	CT	**Arkaprabha Sarangi** Niels Bohr Institute [Copenhagen]	Modeling dust formation in supernovae in the JWST era

12:30pm–12:45pm	CT	**Hiddo Algera** Hiroshima University, National Astronomical Observatory of Japan	Massive dust reservoirs in normal galaxies at redshift 7
12:45pm–1:30pm	**Lunch**[1]		
1:30pm–6:30pm	**Excursion to Varberg fortress**		

Thursday, 28th September, 2023

Chair: Frederic Galliano			
9:00am–9:30am	IT	**Anja Andersen** University of Copenhagen	Dust growth in nearby galaxies
9:30am–9:45am	CT	**Massimiliano Parente** SISSA, INAF	The z<1 drop of cosmic dust abundance
9:45am–10:00am	CT	**Joris Witstok** Kavli Institute for Cosmology	The origin of dust grains within galaxies seen in the first billion years of cosmic time
10:00am–10:15am	CT	**Gina Panopoulou** Chalmers University of Technology	Constraining ISM dust properties with stellar polarization and dust emission
10:15am–11:00am	**Coffee break**		
Chair: Liv Hornekær			
11:00am–11:30am	IT	**Emmanuel Dartois** Institut des Sciences Moléculaires d'Orsay	Influence of grain growth on ices spectroscopic profiles
11:30am–11:45am	CT	**Sandra Wiersma** IRAP, Université de Toulouse III - Paul Sabatier, CNRS, CNES	Molecular content in Si + C dust growth processes for laboratory astrophysics
11:45am–12:00pm	CT	**Leonardo Testi** Università di Bologna	From dust to pebbles: revisiting grain growth in protoplanetary disks
12:00pm–1:30pm	**Lunch**		
Chair: Arka Sarangi			
1:30pm–2pm	IT	**Julia Roman-Duval** Space Telescope Science Institute	The nearby universe:A laboratory to study the cosmic build-up of interstellar dust in galaxies
2:00pm–2:30pm	IT	**Brandon Hensley** JPL/Caltech	Rethinking the Nature of Dust in the Diffuse ISM
2:30pm–2:45pm	CT	**David Gobrecht** University of Gothenburg	Predicting the dust condensation sequence from a bottom-up perspective
2:45pm–3pm	CT	**Jessica Sutter** University of California [San Diego]	Using JWST Photometry to Determine What Sets the PAH Distribution in Nearby Galaxies

[1] According to what you answered in the poll, wraps are provided after the session.

3pm–3:45pm	**Coffee break**		
Chair: Susanne Aalto			
3:45pm–4:15pm	IT	**Hiroyuki Hirashita** Academia Sinica	Dust growth in high-redshift galaxies and its impact on the grain size distribution
4:15pm–4:30pm	CT	**Valentin Le Gouellec** NASA Ames Research Center	Observational constrains on dust grain alignment: from protostellar cores to PDRs
4:30pm–4:45pm	CT	**Aleksandra Leśniewska** Astronomical Observatory Institute, Faculty of Physics, Adam Mickiewicz University, Dark Cosmology Centre	Observational evidence of morphological quenching in dusty elliptical galaxies
4:45pm–5pm	CT	**Ilsang Yoon** National Radio Astronomy Observatory	Rise and fall of anomalous microwave emission in extragalactic star forming regions
5pm–5:15pm	**Poster and quiz prices**		
7pm–11pm	**Conference dinner at Wijkanders**		

Friday, 29th September, 2023

Chair: Arka Sarangi			
9am–9:30am	IT	**Elisabetta Micelotta** Nanoform	Dust destruction in supernova remnants
9:30am–9:45am	CT	**Elizabeth Tarantino** Space Telescope Science Institute	The disappearing act: exploring the PAH deficit at low metallicities
9:45am–10:00am	CT	**Felix Priestley** Cardiff University	Empirical constraints on dust destruction in supernova remnants
10am–10:15am	CT	**Ko-Ju Chuang** Leiden Observatory	Interstellar carbonaceous dust erosion induced by X-rays irradiation of water ice in star-forming regions
10:15am–11:00am	**Coffee break**		
Chair: Frederic Galliano			
11:00am–11:30am	IT	**Le Ngoc Tram** Max Planck Institute for Radio Astronomy	Radiative Torque Disruption and Implications
11:30am–11:45am	CT	**Florian Kirchschlager** Ghent University	From total destruction to complete survival: Dust in supernova remnants at different evolutionary stages
11:45am–12:00pm	**Conclusion**		
12:00pm–1pm	**Lunch**[2]		
1pm–5:45pm	**Excursion to the Onsala Space Observatory**		

[2]According to what you answered in the poll, wraps are provided after the session.

Posters

#	Presenter	Title
1	Maryam Saberi	ALMA observations of titanium and aluminium bearing species in Mira
2	C. Zachary Palmer	Alternative dust grain formation: Pathways of formation from alane and ammonia
3	Arya M Nair	Collision induced dissociation of water pyrene molecular clusters
4	Miora Andriantsaralaza	DEATHSTAR – Accurate mass-loss-rate estimates for AGB stars
5	Stefan van der Giessen	Disentangling galaxy and dust evolution mechanisms through chemical abundances
6	Joseph Nuth	Dust coagulation in oxygen-rich circumstellar outflows
7	Minju Lee	Dust content in a $z \sim 2$ quiescent galaxy
8	Christina Konstantopoulou	Dust depletion of metals from from the Milky Way to $z \sim 6$
9	Monica Relano	Dust grain size evolution in local galaxies as a key to understand galaxy evolution
10	Ekta Sharma	Investigating the Magnetic Fields under stellar feedback using dust polarization
11	Petia Yanchulova Merica-Jones	Dust properties and extinction curves in the magellanic clouds, M31, and M33
12	Pablo Rivière	Dust surface chemistry in the AB Aur protoplanetary disk: observations and models
13	Elvire De Beck	Dusty feedback from massive stars
14	Romain Basalgète	Experimental diffusion of water through porous amorphous carbon dust analogues
15	Andreas Møller Slavensky	Characterization of Mg-rich silicate clusters in the interstellar medium
16	Jun Yang	High resolution spectra of the Galactic Binary Pulsar 4U 1907+09
17	Ilse De Looze	High-resolution view of the inner circumgalactic medium of NGC891
18	Karl Gordon	Interstellar dust extinction from the far-ultraviolet to the mid-infrared
19	Jihye Hwang	Magnetic field revealed by polarized dust emission in G28.34

20	Burcu Günay (Karl Gordon)	Mapping the interstellar dust and ice with JWST
21	Stefan Andersson	Mechanisms of SiO oxidation and dust formation
22	Marco Palla	Modelling the dust cycle in local discs: unveiling the contribution of dust processes at kpc scales.
23	Tom Bakx	Observations of dust in the epoch of reionization
24	Ramón J. Peláez	Plasma generation and characterization of 'dense' and 'fluffy' hydrocarbon cosmic dust analogs
25	Gent Frederick	Project SUPERPIG
26	Joachim Wiegert	Radiative transfer through 3D models of dust clouds around AGB-stars
27	Szanna Zsíros	Serendipitous detection of the dusty Type IIL SN 1980K with JWST/MIRI
28	Giovanni Tedeschi Prades	Simulating dust dynamics in SPH and MFM hydrodynamical simulations
29	Nina Sanches Sartorio	Supernova shocks and dust destruction: what role does the environment play?
30	Emelie Siderud	The effect of dust opacities on winds of carbon-rich AGB stars
31	Thomas Vannieuwenhuyse	Paradigmatic examples for testing models of optical light polarization by spheroidal dust
32	Frederick Gent	Supernova dust destruction in the magnetized turbulent ISM

Talks abstracts

Monday, 25th September, 2023

PDRs4All: JWST's view of the Orion Bar

Els Peeters
Monday, September 25

IT

SETI Institute, 189 Bernardo Avenue, Mountain View, CA 94043, USA (SETI)
Department of Physics & Astronomy & Institute of Earth and Space Exploration, Western University, London ON N6A 3K7, Canada

Mechanical and radiative feedback from massive stars drive the evolution of interstellar matter in our Galaxy and throughout the Universe, from the era of vigorous star formation at redshifts of 1-3 to the present day. Photo-Dissociation Regions (PDRs), where far-ultraviolet photons from these stars create a largely neutral but warm region of gas and dust, are ideal laboratories to study these main feedback processes.

In this talk, we present the first results of the PDRs4All JWST Early Release Science program. We obtained JWST NIRCAM and MIRI images and NIRSpec and MIRI IFU data of the Orion Nebula and the proto-typical PDR, the Orion Bar. We identify and characterize an incredibly rich inventory of spectral features, showcasing emission of HI and HeI recombination lines, ionic lines tracing the ionized and neutral gas, CI recombination lines, fluorescence lines of OI and NI, a wealth of H2 rovibrational and rotational lines, as well as CO, CH+ and HD emission lines, and the aromatic infrared bands.

The observations reveal a hyper-structured molecular cloud edge at small spatial scales of 0.1-1" (0.0002-0.002 pc or 40-400 AU at 414 pc). Towards the Orion Bar PDR, a highly sculpted interface is detected with very sharp edges and density increases very near the ionization front and dissociation fronts. The PDR edge is very steep and is followed by an extensive warm atomic layer as traced by the Aromatic Infrared Bands (AIBs). The transition to the molecular PDR as traced by H2 is very complex and structured with several ridges.

The AIB emission displays an incredible richness of profile shapes and subcomponents. The widths of many AIBs show clear and systematic variations, being narrowest in the atomic PDR template and broadest in the dissociation fronts. The relative strengths of AIB (sub)components vary across the mosaic with the aliphatic 3.4 um AIB being strongest in the dissociation fronts whereas the aromatic 3.3 um AIB peaks in the atomic PDR. All AIB profiles are characteristic of class A sources, except for the 11.2 um AIB profile deep in the molecular zone, which belongs to class B. We attribute this to the presence of small, more labile carriers in the deeper PDR layers that are photolyzed away in the harsh radiation field near the surface.

Dust Grain Properties in the Gas-Rich Absorption Systems of Diverse Galaxies at z<2

Monique Aller

Monday, September 25 **CT**

Georgia Southern University

Dust grain properties in the interstellar and circumgalactic media of galaxies can be studied using quasar absorption systems. The galactic dust grains and gas produce absorption features in the spectra of luminous background AGNs, whose sightlines serendipitously pass through the foreground galaxies. This technique allows investigations into the dust grains in gas-rich galaxies with diverse masses, morphologies, and evolutionary histories, and can probe varied internal environments, ranging from the diffuse interstellar medium to dense molecular clouds. We present results from an ongoing program, using archival Spitzer Infrared Spectrograph (IRS) spectra that cover the 10 and 18 micron silicate features, to investigate dust grain properties in individual quasar absorption systems at z<2. Our spectral measurements include the peak optical depth of the 10 micron feature, the ratio of the 10-to-18 micron features, and the shape and breadth of the absorption features, which allow us to constrain the silicate grain compositions, morphologies, and crystallinities. We summarize our current results about the similarities and differences between the silicate dust grains in varied systems, as a function of galaxy properties. We also compare and contrast the galaxy dust grain properties in two dusty, gas-rich galaxies traced by Damped Lyman-Alpha (DLA) absorption systems at z=0.4-0.5 in which we detect similar strength silicate dust absorption features, but which show differences in the carbonaceous dust, as exemplified by the strength of the 2175 Angstrom feature. We discuss variations in dust depletions in quasar absorption systems, and present preliminary results from a JWST GO-Cycle-1 program investigating silicate dust absorption in gas-rich quasar absorption systems at z of 0.5-1.2 with 2175 A dust absorption features. A better understanding of the diversity of silicate dust grain properties in individual systems, and the connections between the silicate and carbonaceous dust grains, in relation to galactic gas properties and internal environment, may inform models of the evolution of dust and metals in galaxies, as well as observational studies with facilities such as JWST. We acknowledge support from NASA grants NNX17AJ26G and 80NSSC20K0887, and STScI grants for HST-GO-15092 and for JWST-GO-02155.

The dust population in PDRs: impact on PDR structure and observable tracers

Raphaël Meshaka

Monday, September 25 **CT**

Sorbonne Université, Observatoire de Paris, Université PSL, CNRS, LERMA, Paris, France

Dust grains play a key role in the physics and chemistry of the Interstellar Medium. They heat the gas through the photo-electric effect, and therefore influence the thermal structure of the ISM. They absorb the UV radiation of stars that dissociate molecules. They also act as catalysts of the formation of molecules like H2. All these processes depend on the dust population: chemical composition (carboneous, silicates etc.) and size distribution. Multiple dust population models have been proposed (Mathis et al. 1977, Zubko et al. 2004, Draine & Li 2007, Compiegne et al. 2011, Jones et al. 2013). These dust population models propose a various range of grain compositions and size distributions. They have been constrained by dust IR-emission and UV-extinction in the diffuse ISM but, up to now, the impact of these new distributions on the chemistry and the excitation of the gas has never been tested. Our goal is to find a comprehensive model of both, able to explain consistently the gas and grain tracers in various environments. Our goal is to study the link between the dust population and the thermal and chemical structure of PDRs, traced by gas emission lines. We have updated the treatment of dust physics in the Meudon PDR Code (Le Petit et al. 2006) to allow a wide range of possible dust populations to be used in the model, and refined the treatment of photoelectric effect to account for the effect of grain composition. The Meudon PDR code simulates the physics and chemistry of PDRs, solving the chemistry of hundreds of species, the radiative transfer, the thermal balance and the excitation of main species. With this new version of the code, we compare the THEMIS dust population model (Jones et al 2017) with older models (Mathis et al. 1977, Draine & Li 2007), and its impact on the chemical and thermal structure of various environments : diffuse ISM, dense and highly illuminated PDRs such as the Orion Bar, and less excited PDRs such as the Horsehead Nebula. In addition to this theoretical study, we try to get new constraints on the dust population parameters based on gas emission lines observed with JWST, especially H2 ro-vibrational lines.

AstroPAHs: from laboratory experiments to observational diagnostics

Christine Joblin
Monday, September 25

IT

Institut de recherche en astrophysique et planétologie, Université Toulouse III - Paul Sabatier, CNRS : UMR5277, CNES

The interaction of UV irradiation with large carbonaceous molecules, such as polycyclic aromatic hydrocarbons (PAHs), leads to various molecular processes impacting the physical and chemical conditions in star-forming regions [1,2]. Since a complete simulation of these processes in the laboratory is not possible, models must be developed and their results validated by comparison with observational diagnostics. These models are based on experimental results and quantum chemistry calculations that provide quantitative values for molecular parameters and processes. I will focus on two examples. The first is linked to the heating of the gas by thermalisation of the electrons emitted by ionisation, a process known as photoelectric heating. We recently found good agreement between modelled values and observational diagnostics for PAH charge state and PAH heating efficiency [3]. We concluded that PAH ionisation is the primary source of neutral gas heating in diffuse gas at all scales from star- and planet-forming regions to distant galaxies. The second aspect is related to radiative cooling and the analysis of aromatic infrared bands (AIBs), in the context of their observation by the James Webb Space Telescope with unprecedented sensitivity, spectral, and spatial resolutions [4]. Detailed analysis of AIBs requires taking into account molecular diversity and the exciting UV radiation field. In this context, we are developing the LAIBrary project [5], which aims to generate a library of detailed synthetic emission spectra of PAHs and related species in a variety of astrophysical environments, making use of all available molecular information for a realistic representation of the spectral profiles. Important molecular parameters in the emission model include the evolution of the infrared spectrum with temperature [6,7] and the dynamics of infrared cooling in competition with other relaxation processes [8,9]. The quantification of these parameters is the subject of specific experiments that I will present. Ultimately, LAIBrary will enable us to refine our understanding of emitting molecules and use AIBs as observational diagnostics of physical conditions in astrophysical environments. [1] A.G.G.M. Tielens, ARA&A 46, 289 (2008); [2] C. Joblin et al., J. Phys. Conf. Ser. 1412, id. 062002 (2020); [3] O. Berné et al., A&A 667, A159 (2022); [4] O. Berné, E. Habart, E. Peeters, et al., PASP 134, id.054301 (2022); [5] https://cosmic-pah.irap.omp.eu/ ;[6] C. Pech et al., A&A 388, 639 (2002); [7] S. Chakraborty et al., JPC A 123, 4139 (2019); [8] M. Stockett et al., J. Chem. Phys. 153, 154303 (2020); [9] https://anr.fr/Project-ANR-21-CE30-0010

Polycyclic Aromatic Hydrocarbons and dust in star-forming regions and the vicinity of AGN: a JWST view

Ismael Garcia-Bernete

Monday, September 25 **CT**

University of Oxford

Nowadays, it is widely accepted that most galaxies undergo an active phase in their evolution. The impact of the energy released by active galactic nuclei (AGN) in the interstellar medium (ISM) of the host galaxy has been proposed as a key mechanism responsible for regulating star formation (SF). The mid-infrared (IR) is the ideal spectral range to investigate the nuclear/circumnuclear regions of AGN since dust extinction is significantly lower compared to the visible range. Furthermore, it provides unique tracers to study the AGN-SF connection such as H2 rotational lines, fine structure lines and Polycyclic Aromatic Hydrocarbons (PAHs). PAHs are also a powerful tool to characterize the ISM in different environments. Recently, we presented new JWST/MIRI MRS spectroscopy of three Seyfert AGN in which we compare their nuclear PAH emission with that of star-forming regions. This study represents the first of its kind to use sub-arcsecond angular resolution data of local luminous Seyferts with a wide wavelength coverage (4.9-28.1 microns). Our results showed that a suite of PAH features is present in the innermost parts of these Seyfert galaxies. We found that the nuclear regions of AGN lie at different positions of the PAH diagnostic diagrams, whereas the SF regions are concentrated around the average values of SF galaxies. Furthermore, we find that the nuclear PAH emission mainly originates in neutral PAHs while, in contrast, PAH emission originating in the star forming regions favours small ionised PAH grains. Therefore, our results provide evidence that the AGN have a significant impact on the ionization state and size of the PAH grains on scales of 142-245 pc. This is fundamental since PAH bands are routinely used to measure star-formation activity in near and far SF and active galaxies. Finally, I will summarise our ongoing JWST work using cycle 1 observations [id. 1670] and and our prospects for cycle 2 [approved program id. 3535] . In particular, I will focus on our recent study about the survival of PAH molecules in AGN-driven outflows.

A computational anharmonic IR database of nanosilicate clusters at astrochemically relevant temperatures

Zeyuan Tang

Monday, September 25 **CT**

Center for Interstellar Catalysis, Aarhus University

Silicate dust with different compositions, sizes and shapes exhibit varied properties that can be probed by infrared (IR) observations. The interpretation of IR observation depends on spectroscopic data from laboratory measurements and/or quantum chemical calculations. Here we build a computational IR database for nanosilicate clusters with anharmonic and temperature effects considered. The IR calculations are based on machine learning driven molecular dynamics, thereby having the accuracy of ab initio methods and a computational cost comparable to that of classical force fields. The database contains pyroxene and olivine nanosilicate clusters with various sizes and temperatures. Such spectroscopic data are helpful for aiding the interpretation of the upcoming James Webb Space Telescope (JWST) observations and for understanding the properties of silicate dust grains in the interstellar medium (ISM) and in circumstellar environments.

Temperature-dependent optical properties of dust analogues for the interpretation of astronomical observations

Karine Demyk

Monday, September 25 **CT**

Institut de recherche en astrophysique et planétologie (IRAP) CNRS : UMR5277, Observatoire Midi-Pyrénées, Université Paul Sabatier [UPS] - Toulouse III, Université Paul Sabatier (UPS) - Toulouse III

A good understanding of the properties of cosmic dust analogues is essential to study the life cycle of cosmic dust but also to interpret observations of dust-rich environments. As dust is present in astrophysical environments as diverse as interstellar clouds, cold cores, circumstellar envelopes and disks around evolved and young stars, planetary atmospheres, PDRs, etc., it is crucial to study the properties of dust analogues over a wide range of physical conditions in terms of temperature, as well as on the widest possible spectral range.

In this talk I will present the results of experimental studies of the optical properties of silicates dust analogues at low temperature (10-300K) in the mid to far infrared range (5-1000 microns). The comparison of these new optical constants, which are key ingredients of cosmic dust models, with those included in current cosmic dust models will be shown and the impact on astrophysical studies of cold regions in star-forming regions and protoplanetary disks discussed.

I will also present recent results on the optical properties of PAHs as a function of temperature (14-723K) in the mid-infrared domain (2-25 microns). The aim of this work is to retrieve empirical anharmonic parameters that characterise the evolution of the IR spectra of PAHs with temperature. These data is mandatory to simulate the emission of PAHs in a given astrophysical environment and compare the simulated IR spectra with the astronomical Aromatic Infrared Bands (AIBs), which are currently observed with the James Webb Space Telescope (JWST).

These fundamental data on silicate analogues are provided to the astronomical community via the STOPCODA database (https://www.sshade.eu/db/stopcoda) and the Cosmic PAH portal (http://cosmic-pah.irap.omp.eu).

Dark Dust

Ralf Siebenmorgen
Monday, September 25

IT

European Southern Observatory

1) Distance estimates derived from spectroscopy or parallax have been unified by considering extinction by large grains. The addition of such a population of what is called dark dust to models of the diffuse interstellar medium is tested against a contemporary set of observational constraints. By respecting representative solid-phase element abundances, the dark dust model simultaneously explains the typical Milky Way wavelength-dependent reddening, extinction, and emission of polarised and unpolarised light by interstellar dust particles between far-UV and millimetre wavelengths. The physical properties of dark dust were derived. Dark dust consists of micrometre-sized particles and provides significant wavelength-independent reddening from the far-UV to the near-infrared. Light absorbed by dark dust is re-emitted in the submillimeter region by grains at dust temperatures of 8-12K. This very cold dust has frequently been observed in external galaxies. Optical constants for amorphous silicate dust analogous were investigated and mixing 3% in mass of $Mg_{0.8}$ $Fe^{2+}_{0.2}$ SiO_3 to $MgO_{0.5}$ SiO_2, a good fit to the data of the general field of the diffuse ISM was derived that can accommodate up to 5-10% of the mass in dark dust. The additional dimming of light by dark dust is unexplored when supernova Ia light curves are discussed and in other research.

2) The nature of dust in the diffuse interstellar medium can be best investigated by means of reddening curves where only a single interstellar cloud lies between the observer and the background source. Published reddening curves often suffer from various systematic uncertainties. We analyse a total of 110 sightlines toward OB stars with 174 reddening curves. We exclude stars with composite IUE of multiple, with uncertain spectral type photometric variability, and inconsistent parallaxes. In total, 53 stars pass the rejection and were included in the high-quality Milky Way reddening curve sample.

Dust content of galaxies at high redshift

Tomoko Suzuki
Monday, September 25

IT

Kavli IPMU

Dust and gas contents in galaxies are key physical quantities to understand the evolution of galaxies via star formation, gas outflow, and gas inflow. Sub-mm/mm observations over past decades revealed the dust and gas properties of not only dusty galaxies but also UV/optical selected galaxies at z > 1, which allows us to investigate the dust properties of different types of galaxies at high redshift. One of the missing pieces of information is the chemical conditions of ISM in these galaxies. Whereas the formation of dust is considered to be closely related to the gas-phase metallicity, the relation between the two quantities has not been fully investigated yet for galaxies at high redshift. In this talk, I will share our observational study about the dust (and gas) content and gas-phase metallicity of star-forming galaxies at z > 3 and more recent observational studies on the dust properties of high redshift galaxies.

Constraining the dust attenuation law in early galaxies with JWST

Vladan Markov

Monday, September 25 CT

Scuola Normale Superiore, Piazza dei Cavalieri 7, 56126 Pisa - Italy

Constraining the dust attenuation law and its evolution over cosmic time is essential for understanding the properties of the interstellar dust (dust content, grain size distribution, chemical composition) and the dust production mechanisms, along with the global properties of early galaxies. The current standard approach of "a priori" assuming a dust attenuation law based on local sources may not be appropriate for high-redshift galaxies.

I will present a new tool, based on the Spectral Energy Distribution (SED) fitting, which allows for the simultaneous characterization of the dust attenuation properties and global parameters of galaxies without any prior assumption on the dust law. The advantage of using this robust model, is its capability to recover the dust attenuation properties reddened by any well-known, or potential new dust curve that might exist at the Epoch of Reionization (EoR). We apply our new tool to a sample of star-forming galaxies at the EoR, using James Webb Space Telescope (JWST) observations. This approach, along with the new JWST data, offers means of constraining the dust properties of a large sample of galaxies at the EoR.

ALMA view on the dust properties of the HYPERION QSOs

Roberta Tripodi

Monday, September 25 IT

University of Trieste
INAF - Osservatorio Astronomico di Trieste

Dust properties are key elements to understand the assembly and nature of the first QSOs at the Reionization Epoch. Indeed a reliable and accurate determination of the dust properties, through the analysis of the continuum emission, enables us to determine the star formation rate of the QSO’s host galaxy. However, dust masses and temperatures are often determined with huge uncertainties relying only on single-frequency continuum detections. I will present results on the dust properties of some z>6 QSOs, belonging to the HYperluminous QSOs at the Epoch of ReionizatION (HYPERION) sample (Zappacosta+23). HYPERION is a 2.4 Ms XMM-Newton Multi-Year Heritage Programme targeting the titans among z > 6 QSOs, powered by the fastest growing and most massive Super Massive Black Holes (SMBH) at their epoch, and likely assembled from the largest black-hole (BH) seeds, or experienced peculiar, possibly supercritical, mass accretion histories. We successfully proposed and obtained high-frequency ALMA observations for HYPERION QSOs, which enabled us to probe the peak emission of the cold dust spectral energy distribution and therefore to constrain the star formation rate of the QSO’s host galaxies with very high precision (Tripodi+23, Tripodi in prep.). The final goal will be to have a broader picture of the dust properties of high-z QSOs and to discuss the evolutionary scenario of these objects.

Tuesday, 26th September, 2023

There and back again — Dust evolution between diffuse and dense environments — It's complicated

Anthony Jones

Tuesday, September 26 **IT**

Institut d'Astrophysique Spatiale (IAS Orsay)

Within the framework of The Heterogeneous dust Evolution Model for Interstellar Solids (THEMIS) I will discuss what we currently understand about the evolution of dust in the transition between low and high density regions. This evolution involves changes in the dust structural and chemical properties, encompassing: dust growth via carbonaceous (a-C:H) and icy mantle accretion, nanoparticle sweep-up or dust aggregation, mantle disruption, coagulated grain disaggregation, (E)UV photo-processing, radiation pressure sorting or segregation, … Dust evolution is accelerated in the high density, extremely irradiated regions near stars (star formation regions, PDRs and CS discs) and is driven by gas-grain, grain-grain and grain-photon interactions. These processes can occur sequentially, co-spatially and/or co-temporally with changes in the local physical conditions (density, temperature, ionisation state, ISRF, …) and occur in both the forward or constructive and reverse or destructive senses. The primary observational evidence for these evolutionary processes includes: UV to IR extinction variations, changes in the UV extinction steepness, the (dis)appearance of nanoparticle extinction and emission, cloud- and core-shine (C-shine), carbon and oxygen depletion variations, … In order to study dust evolution we therefore need to understand how its size, structural & shape distribution, chemical composition and charge state respond to the local environment.

Dust Evolution across the Orion Bar: new insights from the JWST

Meriem El Yajouri

Tuesday, September 26 **CT**

Institut d'Astrophysique Spatiale (IAS)

The interstellar medium (ISM) is a complex and dynamic environment that plays a crucial role in the formation of stars and planets. Dust is a fundamental component of the ISM, and its properties, including composition, size distribution, abundance, and optical properties, evolve in response to changes in the local environment, such as radiation field and density. In this study, we use data from the JWST program "PDRs4All" [1] to explore the evolution of dust properties in the Orion Bar, a strongly FUV-irradiated photon-dominated region (PDR) at the interface between cold, dense molecular clouds and hot, ionized regions. We model the dust emission in the Orion Bar in seven photometric bands using THEMIS dust model [2] and SOC [3], a 3D radiative transfer code that takes into account variations in the local physical conditions: geometry, density, and irradiation. The JWST allows us for the first time to spatially resolve the steep density gradient at the illuminated edge of the PDR. By considering both carbonaceous nanograins and submicronic grains across the PDR, we derive unprecedented constraints on the properties of the dust grains across the Orion bar. This study provides new insights into the evolution of dust properties in PDRs and demonstrates the power of JWST observations to spatially resolve these regions.

PASIPHAE Survey: Large optical polarimetric sky survey for dust cloud & magnetic field tomography

Siddharth Maharana

Tuesday, September 26 **CT**

South African Astronomical Observatory

PASIPHAE (Polar-Areas Stellar Imaging in Polarization High Accuracy Experiment) project, scheduled to begin in 2023, aims to create the first large stellar polarization map of the sky, spanning thousands of square degrees in the galactic polar regions. This new catalog will enable creation of magnetic field and dust cloud tomography map of the galactic polar regions using stellar polarimetry and GAIA stellar distances as tools. Two WALOP (Wide-Area Linear Optical Polarimeter) instruments, to be mounted on 1 m class telescopes in South Africa and Greece are being developed to measure the linear polarization of stars up to 16 magnitude in SDSS-r broadband with 0.1 % accuracy. WALOPs have been designed to operate with the combined capabilities of one-shot linear polarimetry, low polarization systematic (< 0.05%) and a large field of view of 35× 35 arcminutes, making it a unique astronomical instrument. In a single measurement, WALOPs can measure the linear Stokes parameters I, q and u in the SDSS-r broadband and narrowband filters between 500- 700nm. For each exposure, four images of the full field corresponding to polarization angles of 0, 45, 90 and 135 degrees will be generated and by carrying out differential photometry on these images, the Stokes parameters can be obtained. Some critical challenges in designing WALOPs include- (a) correcting for the spectral dispersion introduced by Wollaston prisms used as analysers, (b) large vi- gnetting and throughput loss for off-axis field objects, and (c) large instrumental polarization. We have developed the complete instrument design including the optical and optomechanical design for WALOPs which overcomes these challenges and are expected to meet the design goals. Both WALOPs are in advanced phases of assembly and integration and are scheduled for commissioning in 2023. I will present the PASIPHAE project details, how its requirements drive the technical goals of WALOP instruments, and our efforts in their design and development.

Small amounts of iron(II) sulphides can significantly affect the SEDs of circumstellar disks

Christian Kranhold

Tuesday, September 26 **CT**

Astrophysical Institute and University Observatory, Friedrich-Schiller-University Jena

Iron(II) sulphides are well-known environment sensitive inorganic compounds of iron and sulphur in our solar system. They range from centimetre-sized macro-crystals down to nanoparticle inclusions in GEMS, IDPs, meteorites, asteroids and comets. Only a few studies claim to have detected extrasolar iron(II) sulphides, for example identifying troilite (FeS) in planetary nebulae. We study the influence of Fe/S ratios on the SEDs of silicate-rich circumstellar disks, including temperature dependencies of free-charge-carrier characteristics and phonon bands. We show that the iron-to-sulphur ratio plays a crucial role in the detection of iron(II) sulphides. As a result, adding just small amounts of iron(II) sulphides to a pure silicate circumstellar disk would increase its flux in the middle- and far-infrared. Both troilite (FeS) and pyrrhotites ($Fe_{1-x}S$, x=0 ... 0.125), cause absorption efficiencies to increase significantly in the visible, near- and mid-infrared in comparison to the far-infrared. There, the troilite phonon bands have a small impact and the pyrrhotite addition does not change the form of the spectrum. Future infrared-space missions could directly detect troilite by phonon bands, whilst the metal-like 'featureless' behaviour of pyrrhotites would only influence the relative SED flux. Such observations would significantly improve our understanding on the composition and history of circumstellar disks.

Assessing the astronomical relevance of interstellar nanosilicate dust grains from IR spectra: theory, experiment and observation

Stefan Bromley

Tuesday, September 26

IT

Institució Catalana de Recerca i Estudis Avançats [Barcelona] (ICREA)
Universitat de Barcelona (UB)

Silicates are ubiquitously found as small dust grains throughout the universe. These particles are frequently subject to high-energy processes in the diffuse interstellar medium (ISM), where they are broken up into many ultrasmall silicate fragments. The resulting species will likely range in size from the atomic scale (e.g. metal ions) to molecular and nanoscales (e.g. nanosilicate grains with a few 10/100s of atoms). Due to their reduced size, even if such grains constitute a small mass percentage of the dust budget, they should form a highly numerous population with potential for seeding dust (re)growth and involvement in astrochemical processes. Here, we assess the structures, spectroscopic properties and astronomical relevance of such nanosilicates by employing accurate theoretical modelling [1] and cluster beam experiments [2]. We highlight the potential role of abundant nanosilicates in: i) the anomalous microwave emission [3], ii) astrochemistry [4], iii) oxygen depletion [2], and iv) dust (re)formation [2] in the ISM. Finally, by considering the distinct infrared (IR) spectra of nanosilicates with respect to that of larger silicate grains, we predict that nanosilicate populations should be observable with the James Webb Space Telescope (JWST). These predictions will be compared with our latest JWST observations considering lines of sight through the diffuse ISM [5]. 1. Structure and Properties of Nanosilicates with Olivine (Mg_2SiO_4)N and Pyroxene ($MgSiO_3$)N Compositions, A. Macia Escatller, Tomas Lazaukas, S. M. Woodley, S. T. Bromley, ACS Earth and Space Chemistry (2019) 3, 2390. 2. Cluster Beam Study of ($MgSiO_3$)+-Based Monomeric Silicate Species and Their Interaction with Oxygen: Implications for Interstellar Astrochemistry, J. Mariñoso Guiu, B-A. Ghejan, T. M. Bernhardt, J. M. Bakker, S. M. Lang, S. T. Bromley, ACS Earth and Space Chemistry (2022), 6, 2465. 3. Assessing the viability of silicate nanoclusters as carriers of the anomalous microwave emission: a quantum mechanical study, A. Macia Escatller, S. T. Bromley, Astronomy & Astrophysics (2020) 634, A77. 4. Trends in the adsorption and reactivity of hydrogen on magnesium silicate nanoclusters, I. Oueslati, B. Kerkeni, S. T. Bromley, Physical Chemistry Chemical Physics (2015) 17, 8951. 5. Illuminating the dust properties in the diffuse ISM with JWST, Zeegers et al., 2021, JWST Proposal. Cycle 1, ID. 2183.

Exploring the dust properties in the nearby diffuse interstellar medium with JWST

Sascha Zeegers

Tuesday, September 26 **CT**

ESA - ESTEC

The diffuse interstellar medium plays an essential role in regulating the energy balance of galaxies, by processing starlight and driving molecule formation. It contains the input ingredients of dense star forming clouds and, consequently, of new stars and planets. Therefore, it is important to understand the properties, formation and evolution of this dust. However, we lack a fundamental understanding of the dust cycle in galaxies and its main elemental building blocks: H, C, O, Si, Mg, and Fe. The wavelength coverage, sensitivity, and spectral resolution of JWST at near- and mid-infrared wavelengths enables us to measure the abundance and determine the composition of the major C and O dust reservoirs in the Milky Way's diffuse interstellar medium. By observing reddened O and B stars in the nearby diffuse interstellar medium we are able to observe dust features in the spectra of these stars that will reveal the dust properties along the line of sight. In this talk we present the first exciting results of Webb Investigation of Carbon Silicates and Ices (WISCI) project in which we study dust along the line of sight of twelve OB stars, using JWST MIRI and NIRCam (GO cycle 1 program id 2183) and HST STIS (cycle 30 program id 17078) spectroscopy. We will show how a global multiwavelength view (FUV - MIR) provides a much deeper understanding of the dust properties in the diffuse interstellar medium.

Studying dust grain properties and growth by combining extinction and depletion measurements in the Milky Way

Marjorie Decleir

Tuesday, September 26 **CT**

Space Telescope Science Institute

Interstellar dust grains come in different sizes and compositions, depending on the environment in which they reside. An indirect, quantitative way to measure the chemical composition of dust grains is via dust depletions: The dust abundance of an element (such as C, Si, Mg, Fe and O) in a given sightline can be derived by comparing the observed gas abundance to a reference total (gas + dust) abundance of that element in that particular sightline. In addition, depletion measurements can help us determine which grain growth mechanism dominates, as accretion of gas particles onto existing dust grains will affect the gas and dust abundances, while coagulation of smaller dust grains does not change the atomic abundances. In our ongoing HST GO program, we are using UV spectra to measure dust depletions in a sample of Milky Way sightlines, that span a range of environments (as traced by their molecular hydrogen fraction). This will pose strong constraints on the detailed dust grain composition and how it varies between different environments, which will allow us to directly assess the accuracy of existing dust grain models. Furthermore, we will combine these depletion measurements with literature UV extinction curves, as well as NIR-MIR extinction curves that will soon be measured with our JWST GO program, for the same sightlines. This will enable us to correlate the properties of the extinction features (such as the UV bump, the 3.4 micron carbonaceous feature and the 10 and 20 micron silicate features) to the atomic abundances and ratios, and as such reveal the carriers of these features. In this talk, I will explain the goals of our synergistic HST-JWST project, and highlight our preliminary results towards constraining dust grain properties and their variation in the Milky Way.

What do dust grains look like at the onset of the star and disk formation sequence ?

Anaëlle Maury
Tuesday, September 26 **IT**

Unité Mixte CEA/CNRS AIM, Université Paris Saclay

The formation and properties of exoplanetary systems is a fascinating question, which has been at the heart of our quest to define mankind and the conditions for life to develop in a broader context. Observations suggest there should be billions of planets in our Galaxy alone. What are the physical process that make planet formation so likely ? Which local conditions are required to transform the stardust of the interstellar medium into pebbles around young stars, and grow these further into planets ? Investigating the dust evolution along the star formation sequence is key to provide a complete picture of the planet formation scenario.

Moreover, the properties of dust grains in star-forming structures are crucial because they regulate some of the key physical processes at work while the star and its disk are being built. For example, it has been shown that the amount of small grains is a key parameter to set the efficiency of magnetic process allowing to regulate the angular momentum of the infalling material during protostellar mass build-up, as they may be the main charge carriers in such environments.

In this talk, I will provide a global outlook on the progresses made in the recent years to investigate the properties of dust around the youngest stellar objects, embedded protostars, and the pristine circumstellar disks observed around them. I will put a special emphasis on describing some puzzling observations and their comparison to state-of-the-art physical models of protostars. I will discuss how these data suggest the need to develop revised dust models, in an attempt to describe the early evolution of dust grains towards future planetary seeds.

Modelling the cold dust in nearby spiral galaxies with radiative transfer

Angelos Nersesian
Tuesday, September 26 **CT**

Ghent University

Cosmic dust grains are one of the fundamental ingredients of the interstellar medium (ISM). Despite of their limited contribution to the total mass budget, dust grains play a significant role in the physical and chemical evolution of galaxies. Over the past decade, our knowledge on the cosmic dust in nearby galaxies has increased substantially thanks to the availability of observational data from UV to far-infrared wavelengths. However, one part of the spectrum, the mm range, has largely remained unexplored. We aim to take advantage of the new, high-resolution data in the mm range observed with the NIKA2 instrument. Combining these new observational data with our radiative transfer framework, would allow us to accurately model the interplay between starlight and dust in a sizeable sample of spatially-resolved nearby galaxies. I will present the methodology of our dust radiative transfer modelling and its application to a small group of face-on spiral galaxies. I will highlight which modelling steps need to be improved, and how the new NIKA2 data would allow us to firmly characterize the physical properties of the very cold dust (<15K), as well as to quantify the importance of different emission mechanisms in the mm.

The X-ray view of dust in the Milky Way

Elisa Costantini
Tuesday, September 26 **CT**

SRON Netherlands Institute for Space Research
Astronomical Institute Anton Pannekoek

In the last years tremendous improvement in our understanding of interstellar dust (ID) in the X-rays has been made. Thanks to accurate modelling, derived from new dust laboratory measurements, X-rays proved to be a powerful tool to investigate the chemistry, size and crystallinity of dust along our line of sight. By studying the light absorbed by bright background X-ray sources, several dust environments, from diffuse to dense regions, can be investigated. More often than not, X-ray studies challenged our understanding of dust formation and structure (e.g. Zeegers et al. 2017, 2019; Rogantini et al. 2019, 2020; Psaradaki et al. 2020, 2022, Costantini & Corrales 2022). X-rays are able indeed to provide also complementary information with respect to longer wavelength. In this contribution we will review the state-of-art from the X-ray point of view and the new science window that upcoming X-ray missions (e.g. XRISM, to be launched in Aug 2023) will open.

Dust Properties from the Lab applied to young disks: 3D-printing and a Microwave Analogy Experiment

Francois Menard
Tuesday, September 26

IT

IPAG- Institut de Planetologie et d'Astrophysique de Grenoble

To set the stage of this review, I will very briefly present some of the latest observational attempts to reveal dust properties in protoplanetary disks. Dust sizes and chemical composition of dust in disks have been studied abundantly in the past via, e.g., spectral energy distributions and near- and mid-spectroscopy. In this review I will place a special emphasis on recent attempts to highlight the particle shapes instead. This can be done via the measurements of their scattering properties, i.e., intensity and linear polarisation phase functions, from the optical to the millimetric wavelength range. These recent advances are particularly interesting to connect the dust properties in disks to the dust evolution and growth mechanisms, a better understanding of which is needed to advance our knowledge of the first stages of planet formation. To reveal the full meaning of these "phase functions", it is necessary to compare them with a database of the "measured" or "calculated" scattering properties of complex dust particles, be them irregular, with rough surfaces, or of fractal nature. I will therefore spend most of the review to present recent efforts to measure the scattering properties of complex dust particles from Laboratory Experiments. In particular I will describe the Micro-Wave Analogy experimental set-up we have been developing recently. I will describe the experimental set-up itself as well as the methods we have developed to prepare relevant dust analogs via 3D-printing. This implies using/developing "printable" materials with relevant refractive indices for astronomical dust. I will wrap up by describing recent measurements and results and compare them with those from purely numerical methods.

The influence of a clumpy outflow and companion star on the surface composition of AGB dust

Marie Van De Sande

Tuesday, September 26 **CT**

University of Leeds

The asymptotic giant branch (AGB) phase of stars of low-to-intermediate initial mass is characterised by strong mass loss via a stellar wind, which is thought to be propelled by a pulsation-enhanced dust-driven outflow. The stellar wind creates an extended circumstellar envelope (CSE), that is a rich astrochemical laboratory: close to 100 molecules have been detected in CSEs, together with various types of newly-formed dust. Thanks to their outflows AGB stars are important contributors to the chemical enrichment of the interstellar medium (ISM), contributing about 70% of the total stellar dust production rate. Understanding the dust evolution cycle in the ISM crucially depends on better understanding the composition of its starting point, i.e., stellar dust. Observations of AGB outflows continue to reveal their complexity. Spherical asymmetries are ubiquitous and thought to be caused by binary interaction. Additionally, dust-gas chemistry plays a role in higher density outflows, accreting gas-phase material onto the dust. We have combined our previous chemical model developments into the most chemically and physically advanced chemical kinetics model of AGB outflows to date. The model includes a porous density distribution, comprehensive dust-gas chemistry, and internal UV photons originating from a close-by companion star. The photoprocessing of volatile complex ices into refractory organic material is also included. We disentangle how the size and composition of the ice mantle and refractory organics depends on the clumpiness of the outflow, the presence of a companion star, and the grain size distribution of the dust. In addition to studying the surface chemistry and the composition of the ices and refractory material on the dust's surface, we also identify gas-phase tracers of dust-gas chemistry. We present suites of molecules to retrieve the specific physical and chemical properties of observed outflows and the evolution of the surface composition of the dust. These will help guide the next suite of observations of both the gas phase and the ice phase and provide valuable tools to better understand the input of stellar dust to the ISM.

The far-UV-extinction-to-H2 correlation and insights from IR emission in photodissociation regions

Dries Van De Putte

Tuesday, September 26 **CT**

Space Telescope Science Institute

In a recent publication, we discovered a strong linear correlation between the far-UV rise of galactic extinction curves, and the column density of H2. This extinction does not scale with HI, meaning that the carrier of the far-UV rise and H2 are co-spatial. While the exact interpretation still open, one option is that the surfaces of the far-UV rise grains are directly responsible for the formation of H2. Alternatively, H2 and the grains in question could be related because their survival depends on similar shielding requirements.

A clue to the interpretation of this H2-extinction correlation, is likely found in photodissociation regions (PDRs). These regions are at the border between atomic and molecular hydrogen gas, where interstellar clouds are illuminated by UV-bright stars, showing a rich and bright spectrum of IR bands. We present spatially resolved IFU spectroscopy of the Orion Bar from the PDRs4All program, the Horsehead, and NGC 7023 (GTO program, data acquisition scheduled). An initial result for the Orion Bar NIRSpec data, is that the 3.4 micron band has a component which appears primarily where excited H2 lines are bright. We will obtain NIRSpec data for the other two objects soon. This clue, the presence or lack of other correlations, and the previously discovered far-UV-extinction-H2 relationship, can serve as new constraints for dust models addressing the far-UV rise.

The Si K Edge Gas and Dust Optical Depths Toward the Galactic Bulge

Jun Yang
Tuesday, September 26 **CT**

Massachusetts Institute of Technology

Knowledge of the dust content in interstellar matter is important to our understanding of the composition and evolution of the interstellar medium. The Chandra High Energy Transmission Grating (HETG) Spectrometer provides a unique opportunity to measure X-ray absorption of interstellar dust and its compositions through the X-ray edge absorption structure. We measure gas and dust optical depths at Si K toward nine bright low-mass x-ray binaries in the Galactic Bulge with very high-precision and pileup-free spectra. We include a likely instrumental feature affecting the Si K edge structure in our analysis. While gas optical depths grow consistently with broadband hydrogen-equivalent columns, the dust optical depths do not. Calculations including dust self-shielding show that the observed dust optical depths can be explained by variations in dust grain columns between various lines of sight. At least three grain column regimes can be identified toward the Galactic Bulge. While grain sizes define the self-shielding effect, variations in grain size distributions do not seem relevant. This shows that the gas-to-dust optical depth ratio toward sources in the Galactic Bulge is not homogeneous. The dust optical depths also roughly correlate with molecular hydrogen columns. Lowly ionized Si K contributions toward the Galactic Bulge were detected but are very small. We also find Si xiii absorption with velocity widths of 800–1100 km s-1, which we attribute to the circumbinary medium.

Wednesday, 27th September, 2023

Dust in AGB Stars

Martha Boyer
Wednesday, September 27 **IT**

Space Telescope Science Institute

Asymptotic Giant Branch (AGB) stars have long been thought to be a source of dust injection into the Interstellar Medium. In the Spitzer era, several studies surveyed nearby galaxies in the infrared (IR) to determine AGB dust composition and dust production rates, with particular focus on AGB stars in the Magellanic Clouds. I will summarize those and other recent studies of AGB dust, and discuss recent/upcoming results from the JWST. JWST is able to probe far more distant galaxies than were previously reachable in the IR, expanding investigations to lower and higher metallicities and providing more complete samples of this short-lived, and thus rare, stellar phase.

The contribution of dust from AGB stars to the ISM

Matthias Maercker

Wednesday, September 27 **CT**

Chalmers University of Technology

The detection of pre-solar grains in meteorites shows that at least some of the dust from asymptotic giant branch (AGB) stars survives the transition into the ISM. It is likely that these grains act as seeds for further dust-growth in the ISM leading to the final observed interstellar dust. I will present a detailed analysis of the dust emission observed with Herschel/PACS at 70 and 160 micron towards wind-ISM interaction regions around a sample of 22 carbon and oxygen-rich AGB stars. My results show that there is a tendency for the grains in the wind-ISM interaction regions to be relatively large (approx. 2 micron), while several uncertainties that affect commonly made basic assumptions on interstellar dust (e.g., composition and morphology) become obvious. This may have severe implications for our understanding of interstellar dust and their effect on the chemical evolution of the ISM. Interstellar dust grains contribute fundamentally to the chemical evolution of the ISM. They provide surfaces for molecular chemistry, can incorporate complex molecules, and shield the molecules from destruction by the interstellar radiation field. However, the dust observed in the ISM is distinctly different from the dust observed in the circumstellar envelopes around evolved stars. The physical conditions in the regions where the stellar wind interacts with the ISM may lead to significant reprocessing of the grains, strongly affecting properties like the size, structure, geometry, and composition of the grains. Our lack of understanding affects our knowledge of the chemical feedback to the ISM from evolved stars, and the origin of the cycle of dust in the ISM. We calculated 3-dimensional radiative transfer models of the thermal dust emission to constrain the geometry of the interaction regions, the total dust masses and temperatures, and the properties of the dust grains. The results show a path forward in investigating the origin of interstellar dust, the cycle of dust in galaxies, and the effect on the chemical evolution of the ISM.

Stardust: From micro-physics to global dynamics

Susanne Höfner

Wednesday, September 27 **CT**

Department of Physics and Astronomy, Uppsala University

Dust is a critical agent in cool giant stars, driving their winds through radiation pressure. The resulting heavy mass loss dominates the evolution of these stars, turning them into white dwarfs. The local conditions in the close stellar environment, set by convection, pulsation and radiation, determine where and what types of dust can form. The properties of the dust grains, in turn, affect the dynamical structure of the outer atmosphere and wind. In our detailed radiation-hydrodynamical models we investigate this interplay of micro- and macro-scale processes, and how it shapes the complex morphology and dynamics of the emerging stellar wind around AGB stars. In this contribution we discuss recent results, including gradual Fe-enrichment of wind-driving silicate grains, and the first global 3D RHD models of AGB stars with dust-driven winds.

Small pieces make up the big story

Leen Decin

Wednesday, September 27 **CT**

Instituut voor Sterrenkunde, KU Leuven (KUL)

Small pieces make up the big story. And these small pieces are here interstellar molecules, Polycyclic Aromatic Hydrocarbon (PAH) molecules. And the big story is the Universe, galactic and extra-galactic. PAH molecules provide a tool to probe macroscopic aspects of the Universe, and vice-versa offers the harsh environment of space unique insight in microscopic processes controlling formation and destruction, excitation and relaxation of individual molecules. PAHs are believed to play a significant role in the process of dust growth and formation in the interstellar mediums. Under certain conditions, PAHs can aggregate and form small clusters or nanoparticles, which can act as seeds for the subsequent growth of larger dust grains. PAH molecules are responsible for infrared emission features in a large variety of (inter)stellar environments, including HII regions, young stellar objects, post-Asymptotic Giant Branch stars, planetary nebulae, nuclei of galaxies, and ultraluminous infrared galaxies. They lock up some 10% of the elemental carbon, and together with carbon monoxide (CO) form the main molecular reservoirs of carbon. As such, the story of interstellar organic chemistry is undeniably linked with the story of PAH molecules. In this lecture, I will review some old and new knowledge on PAH molecules and their role in dust formation. I will touch on the question whether only the most stable PAH molecules survive the harsh conditions of hot spots in photodissociation regions, or whether we should interpret this survival of the fittest in a Darwinian way, i.e. "It is not the strongest species that survives, nor the most intelligent, but the one most responsive to change". I will end with a - maybe controversial - example based on a multi-disciplinary effort, combining new laboratory experiments, quantum chemical calculations, and astrophysical modelling that shows how buckyball-metal complexes can be promising carriers of unidentified infrared emission bands.

Dust millimetre emission in Nearby Galaxies with NIKA2/IRAM-30m: major challenges and latest results of the IMEGIN Large Program.

Lara Pantoni

Wednesday, September 27 **CT**

IAS, Irfu/Dap

The millimetre wavelength domain of the spectral energy distribution of galaxies is one of the least explored wavelength domains, yet it contains emission from three fundamentally important physical processes: thermal emission from dust, free-free emission from ionized gas and synchrotron emission from relativistic charged particles moving in the galactic magnetic field. The NIKA2 camera (IRAM-30m telescope), observing at 1 mm and 2 mm, provides critical observations for input into comprehensive SED models and allows us to: 1) disentangle spatially resolved galaxy spectral energy distribution from dust contribution, free-free and synchrotron emission; 2) constrain the evolution of the dust-to-gas mass ratio within galaxies, which provides a direct link to the chemical evolution of galaxies and the reservoirs for dust production; 3) study the microscopic properties of dust, i.e. constraints on millimetric opacity; 4) study the sub-millimetre excess in galaxies, the origin of which is still unknown. These are some of the main objectives of the IMEGIN Large Program (Interpreting the Millimetre Emission of Galaxies with IRAM-NIKA2; PI S. Madden), targeting 22 nearby galaxies in the millimetre continuum regime with the NIKA2 camera. The NIKA2 millimetre data, combined with a suite of multi-wavelength observations from mid-infrared to radio, including CO and HI, allow us to model the IR-to-radio SED and put constraints on interstellar medium and dust grains properties of galaxies. Our SED analysis (performed globally and locally) makes use of the state-of-the-art hierarchical bayesian fitting code HerBIE with the prescriptions of the dust evolution model THEMIS, which is anchored to the laboratory-measured properties of interstellar dust analogues. During my talk, I will focus on the major challenges linked with data post-processing and uncertainty propagation, large-scale emission filtering in NIKA2 maps (due to atmosphere subtraction during the data reduction process) and I will present the latest scientific results.

Laboratory studies on the production and processing of major cosmic dust components in laboratory

Cornelia Jäger
Wednesday, September 27 IT

Laboratory Astrophysics Group, Max Planck Institute for Astronomy, Heidelberg, and Institute of Solid State Physics, Friedrich Schiller University Jena

Refractory dust grains comprising silicates, oxides, metals, sulfides, and carbon condense in circumstellar environments around evolved stars and in the interstellar medium at temperatures ranging from 10 K up to about 2000 K. The dust attests its existence by the interstellar extinction and polarization, IR emission and absorption spectra, and elemental depletion patterns. Dust grains are constantly processed or even destroyed by energetic photons, ions, and shocks in nearly all astrophysical environments including the diffuse interstellar medium, molecular clouds, and protoplanetary disks. In various astrophysical environments, dust grains are covered by molecular ices and therefore, contribute or catalytically influence the chemical reactions in these layers. Eventually, dust is the basic material for the formation of planets, asteroids, and comets. Laboratory experiments are desperately required to understand the evolution and life cycle of cosmic dust grains not only to identify cosmic dust components and to define building materials for larger bodies such as planets and comets, but also to obtain information on conditions in the corresponding astrophysical environments. This talk considers recent progress in laboratory approaches on dust and dust/ice experiments that help to understand the formation processes of different dust materials, but also demonstrates the possible significant changes in composition and structure as well as erosion of major dust components.

High-resolution view of the inner circumgalactic medium of NGC891

Ilse De Looze
Wednesday, September 27 IT

Department of physics and astronomy, Ghent University

The baryonic cycling of the material pushed out of the galactic midplane by stellar and/or supernova feedback processes, and the fallback of cool circumgalactic gas onto the disk is uniquely observed in edge-on galaxies. As such, NGC 891 is a perfect target to study the life-cycle of baryonic material. Its virtually perfectly edge-on inclination (89.7 degrees) and closeness (9.6 Mpc), together with the sensitivity and resolution of JWST imaging instruments lets us probe faint structures in the circumgalactic medium down to 10 pc scales. We were able to confirm the presence of dust out to 5 kpc (S/N >= 3), forming a loop-like structure, tentatively suggesting the existence of a galactic fountain. Using unsharp masking techniques and Spitzer/IRAC 8 micron data, we investigate the connection of these filament-like structures to the disk, and their association to potential star forming regions, which could be the drivers of expelled interstellar material outside of the galaxy. We also track the distribution of small clumps, whose sizes range from 10 to 30 pc, suggesting the existence of small pockets of processed dust grains out in the CGM.

Modeling dust formation in supernovae in the JWST era

Arkaprabha Sarangi

Wednesday, September 27 **CT**

Niels Bohr Institute [Copenhagen]

The formation of molecules, molecular clusters, and solid grains of dust, control the chemical budget of supernovae (SNe) from their nebular phase to the remnants. Quantifying the mass and composition of dust in SN ejecta enable us to study the hydrodynamics of the SNe, in terms of the nature of the explosion, geometry of the ejecta, the mass of the ejecta, pre-explosion activities of the massive star, degree of mixing and clumpiness of the layers induced by the explosion. Based on the type of progenitor, theories predict the dominance of C-rich (expected in smaller progenitor stars) or O-rich dust components (expected in larger progenitors). Moreover, the timescales of dust formation for individual species differs based on the densities of the clumps and the cooling rates defined by elements present in those clumps. In recent years, we have realized that the interaction of the SN shock with circumstellar environments influence the physical and chemical evolution of the SN profusely. In many interaction-dominated SNe, dust is assumed to form in the post-shock gas (behind the SN blast wave), with a larger survival rate when merging with the ISM. The molecules are crucial in determining the pathways to form various dust grains, in addition to being responsible for the rapid cooling of the gas. Possibility of detection of molecules in extragalactic SNe, decades after the explosion, provides the critical evidence for determining the pathways of dust formation. In addition, tracing the rate of dust production until late times helps us understand the mechanism of dust growth, which is connected to the compactness of the core and the mantle of these dust grains. The destruction of these grains by the reverse shock is affected by this outcome. At any given time, the range of dust temperatures in SNe can vary over a wide range, thereby radiating at all wavelengths from near-IR to submm wavelengths. Several evidence points towards the likely presence of large masses of cold dust, however prior to the JWST era we had no tools to test that. Thanks to the ongoing detections of dust reservoirs in several extragalactic supernovae, using the mid-IR data from the JWST, we now have a much improved understanding of the role of SNe as dust producers in galaxies. In my talk, I will present the current state-of-the-art in the field of supernova dust, explaining the physics and chemistry of dust formation in such environments.

Massive Dust Reservoirs in Normal Galaxies at Redshift 7

Hiddo Algera

Wednesday, September 27 **CT**

Hiroshima University
National Astronomical Observatory of Japan (NAOJ)

In recent years, ALMA has detected (sub-)millimeter continuum emission from dozens of galaxies at z > 6.5, thereby suggesting that the ISM of high-redshift galaxies is rapidly enriched by dust. However, to accurately constrain the build-up of dust in the distant Universe, following up high-redshift dust reservoirs with multi-band ALMA continuum observations is essential. Such observations are needed to break the observational degeneracy between dust mass and temperature, and hence provide the accurate dust masses required to test theoretical models of dust production in the early Universe. In this talk, I will discuss new multi-band ALMA observations of normal star-forming galaxies at z 7, and show that some of these have already built up dust reservoirs of >1e8 Msun only 700 Myr after the Big Bang. Next, I will present new measurements of the infrared SED of a galaxy at redshift 7.3, which has been carefully constrained through ALMA observations in six distinct bands. As a result, its dust emissivity index (beta) has been measured with great precision, suggesting a steeper value than what has typically been observed in local and intermediate-redshift galaxies. I will discuss this intriguing finding in detail in the context of the dust properties and production mechanisms of high-redshift galaxies.

Thursday, 28th September, 2023

Dust growth in nearby galaxies

Anja Andersen

Thursday, September 28 **IT**

University of Copenhagen

Studies of nearby galaxies provide unique constraints on fundamental dust processes, as nearby galaxies span a wide diversity of environmental conditions – such as metallicity, mass, star formation activity, gas mass fraction, and stellar age – offering a greater dynamic range than is seen in the Milky Way. Nearby galaxies thereby provide the opportunity to observe dust in extreme conditions. As the evolution of the cosmic dust content and the cycle between metals and dust in the ISM plays a fundamental role in galaxy evolution, nearby galaxies can also be seen as a necessary intermediate step towards understanding distant galaxies as they are spatially resolved and typically have better wavelength coverage and a more complete line inventory. I will review what is currently known on the growth of dust in nearby galaxies, with a particular emphasis on the dust-to-metals ratio and the variation of the gas-to-dust ratio with metallicity and measurements of depletion as a tracer of dust properties and the destruction-growth cycle.

The z<1 drop of cosmic dust abundance

Massimiliano Parente

Thursday, September 28 **CT**

SISSA
INAF - Osservatorio Astronomico di Trieste

Observations suggest that the amount of galactic dust in the Universe decreased by a factor of 2-3 over the past 8 billion years. However, explaining this trend usually remains a challenge for existing cosmological models of galaxy evolution. In this talk I will present a recent work that uses a semi-analytic model (SAM) to investigate this phenomenon in detail. In particular, the latest version of the L-Galaxies SAM has been extended with a state-of-the-art dust model and a new disc instability treatment, which triggers bulge and central black hole growth. The model predicts a galactic dust drop from z 1 to z=0: it is the first time that a SAM well agrees with the observed trend. I will discuss the role of the different dust processes (e.g. grain growth, destruction), as well as the significance of the disc instability treatment for producing this result. I will also briefly discuss the model predictions concerning extra-galactic dust.

The origin of dust grains within galaxies seen in the first billion years of cosmic time

Joris Witstok

Thursday, September 28 **CT**

Kavli Institute for Cosmology - University of Cambridge

Interstellar dust captures a significant fraction of elements heavier than helium in the solid state and is an indispensable component both in theory and observations of galaxy evolution. Even in the early Universe, dust emission is a primary coolant of the interstellar medium (ISM) and facilitates the gravitational collapse and fragmentation of gas clouds from which stars form, while altering the emission spectrum of galaxies from ultraviolet (UV) to far-infrared wavelengths through the reprocessing of starlight. However, the astrophysical origin of various types of dust grains remains an open question, especially since significant dust production on short timescales has proven challenging for theories of dust formation. In this talk, I will present the detection of the broad UV absorption feature around 2175 Å in deep JWST/NIRSpec spectra of galaxies up to the first billion years of cosmic time, at a redshift of z 7. This dust attenuation feature has previously only been observed spectroscopically in older, more evolved galaxies at redshifts of z < 3. Our findings provide direct evidence for the early presence of carbonaceous grains giving rise to this feature, often thought to be polycyclic aromatic hydrocarbons (PAHs) produced on timescales of hundreds of millions of years by asymptotic giant branch stars. Instead, our results suggest a more rapid production scenario, likely in supernova (SN) ejecta, potentially implying a different type of grains as the cause of the absorption. I will further show that substantial dust production on such short timescales is required to explain the high dust yields seen in a sample of 17 galaxies in the early Universe (4 < z < 8) with well-sampled far-infrared spectral energy distributions (SEDs) compiled from the literature. The observed dust masses, whose degeneracy with dust temperature can only be mitigated with a well-constrained SED, in several sources significantly exceed the prediction of stellar dust build-up even under a highly optimistic dust yield, again pointing towards additional and/or accelerated dust production channels.

Constraining ISM dust properties with stellar polarization and dust emission

Gina Panopoulou

Thursday, September 28 **CT**

Chalmers University of Technology

Interstellar dust causes the polarization of background starlight. When combine with polarized dust emission, this dust-induced-polarization gives a firm handle on dust properties. Recent results combining stellar polarimetry and polarized dust emission have nessessitated a re-assessement of existing dust models. I will discuss what we have learned by these joint studies about the polarizing efficiency of dust. I will present a new database for stellar polarization that can be mined to gain further observational constraints on the dust properties. I will conclude with future prospects for improving dust models in the general ISM based on these developments.

Influence of grain growth on ices spectroscopic profiles

Emmanuel Dartois

Thursday, September 28 **IT**

Institut des Sciences Moléculaires d'Orsay

Interstellar dust grain growth in dense clouds and protoplanetary disks, even moderate, affects the observed interstellar ice profiles as soon as a significant fraction of dust grains is in the size range close to the wave vector at the considered wavelength. The continuum baseline correction made prior to analysing ice profiles influences the subsequent analysis and hence the estimated ice composition, typically obtained by band fitting using thin film ice mixture spectra. We explore the effect of grain growth on the spectroscopic profiles of ice mantle constituents, with the aim of understanding how it can affect interstellar ice mantle spectral analysis and interpretation. Using the Discrete Dipole Approximation for Scattering and Absorption of Light, the mass absorption coefficients of several distributions of grains – composed of ellipsoidal silicate and carbonaceous cores with water and carbon dioxide ice mantles – are calculated. A few models also include pure carbon monoxide in the ice mantle. We explore the evolution of the size distribution starting in the dense core phase in order to simulate the first steps of grain growth up to three microns in size. The resulting mass absorption coefficients are injected into RADMC-3D radiative transfer models of spherical dense core and protoplanetary disk templates to retrieve the observable spectral energy distributions. Calculations are performed using the full scattering capabilities of the radiative transfer code. We then focus on the particularly relevant calculated profile of the carbon dioxide ice band at 4.27 microns. The carbon dioxide antisymmetric stretching mode profile is a meaningful indicator of grain growth. The observed profile toward dense cores with the Infrared space observatory and Akari satellites already showed profiles possibly indicative of moderate grain growth. The observations with the JWST present distorted profiles that will allow constraints to be placed on the extent of dust growth. The more evolved the dust size distribution, the more the extraction of the ice mantle composition will require both understanding and taking into account grain growth.

Molecular content in Si + C dust growth processes for laboratory astrophysics

Sandra Wiersma

Thursday, September 28 **CT**

IRAP, Université de Toulouse III - Paul Sabatier, CNRS, CNES

The outflows of C-rich AGB stars produce a rich, dusty chemistry in which silicon carbide (SiC) dust is of major importance. It is the second-most common form of dust after amorphous carbon (a-C). Polycyclic aromatic hydrocarbons (PAHs) are often put forward as an intermediate towards a-C growth, but the formation mechanisms of the PAHs themselves are not clear. Laboratory simulations with an increased chemical complexity, for instance through the addition of Si, are needed. We study the hydrocarbon chemistry of different forms of carbon in reaction with silicon using two different dust reactors. In the Stardust setup [1], Si and C atoms are produced by sputtering of solid targets with Ar+-ions, and aggregate in the presence of a lateral H2 flow. Reaction temperatures are estimated at 500 – 1000 K. In PIRENEA 2 [2], one or two solid rods (Si and/or C) are laser vaporized in the presence of a He pulse which can be seeded with H2 or C2H2. Temperatures are estimated at < 4000 K in the plasma plume. For both setups, dust (analog) deposits were prepared for ex-situ analysis with the high-resolution laser desorption/ionization molecular analyzer AROMA [3]. The AROMA analyses of samples from both setups reveal a large variety of hydrocarbons, in particular of PAHs whose detection is optimized by the used laser scheme. The PAH formula with the highest intensity in most mass spectra is C16H10+, mimicking meteoritic findings [4]. Note that C16H10+ has several isomers. The Stardust experiment shows that Si strongly promotes the formation of PAHs compared to C-only experiments [1]. In PIRENEA 2, the addition of Si promotes the growth of PAHs with odd numbers of carbon. We conclude that Si likely plays a significant role in circumstellar hydrocarbon chemistry. Future research will examine the role of iron. Acknowledgements: We thank the European Research Council for funding support under Synergy Grant ERC-2013-SyG, G.A. 610256 (NANOCOSMOS) and l'Agence Nationale de la Recherche in France under project ANR GROWNANO (ANR-21-CE29-0001). We also thank Loïc Noguès for technical support. References: [1] L. Martínez et al. (2020). Nat. Astron., 4(1), 97–105. [2] A. Bonnamy et al., (2018), 22nd Int. Mass Spectrom. Conf., Florence [3] H. Sabbah et al., (2017), Astrophys. J., 843(34), pp. 1–8 [4] H. Sabbah et al. (2022) Astrophys. J. 931(2), 91.

From dust to pebbles: revisiting grain growth in protoplanetary disks

Leonardo Testi

Thursday, September 28 **CT**

Università di Bologna

The initial stages of planet formation involve the growth of dust particles from submillimetre sizes to pebbles and planetesimals. Much of the early observational work focused on the characterization of the submillimetre emissivity of dust in protoplanetary disks from the mid-90s to the mid-2010s. In the last 5-10 years ALMA has transformed the field bringing to light some of the limitations of the initial measurements and analyses. In this contribution I will discuss our current understanding of grain growth and trapping in disks from submillimetre observations, presenting also the results of recent multi wavelength population studies, as well as multi-wavelength high angular resolution observations of individual disks. Taken together these results highlight the higher than previously appreciated importance of optical depth in the analysis of the submillimetre spectra of protoplanetary disks. The combined analysis still indicates the presence of significantly large grains in protoplanetary disks, but highlights the importance of early growth, early planet formation and dust reeneration (through larger bodies collisions). I will show the combined result of multi-wavelength spatially resolved ALMA observations of the protoplanetary disk populations in Ophiuchus, Lupus, Chamaeleon and Upper Scorpius regions, and will put the current results and constraints on dust properties and evolution in the context of planet formation, also highlighting the major challenges in the field that will be addressed by future observations at radio and infrared wavelengths.

The nearby universe:A laboratory to study the cosmic build-up of interstellar dust in galaxies

Julia Roman-Duval
Thursday, September 28 IT

Space Telescope Science Institute

A key component of the baryon cycle in galaxies is the cycle of metals between the gas and the dust phases in the neutral interstellar medium (ISM). The resulting variations in the abundance of interstellar dust have important implications for how accurately we can trace the chemical enrichment of the universe over cosmic time. Furthermore, variations of the abundance and properties of dust within and between galaxies profoundly affects their evolution, given the key role that dust plays in the chemistry, radiative transfer, and thermodynamics of galaxies. In this talk, I will present results from two observational efforts to characterize how the dust abundance varies with metallicity and gas density using nearby galaxies as laboratories. The first method uses emission-based tracers of the interstellar medium (FIR, HI 21 cm, CO rotational emission) to map their dust and gas content, while the second method uses UV absorption spectroscopy with Hubble to directly count metals in the gas-phase. Both types of studies demonstrate a significant increase of the abundance of dust (and of the fraction of metals locked in dust) with gas density that is very likely due to dust growth in the ISM (with a density-dependent timescale). Furthermore, we find that the fraction of metals locked in dust decreases with decreasing metallicity, by a factor of 30 from the Milky Way to Sextans A (10% solar metallicity) at log NH = 20 cm-2 (factor 2.3 at log NH = 21 cm-2). This variation of the dust-to-metal ratio is predicted by chemical evolution models that include dust growth in the ISM, dust destruction by supernova shocks, and dust dilution by inflows of pristine gas. However, a tension still remains between, on the one hand, dust-to-gas ratio measurements obtained from FIR emission in nearby galaxies and chemical evolution models, and on the other hand, dust-to-gas ratio estimates from rest-frame UV spectroscopy in nearby galaxies and high-redshift neutral gas systems.

Rethinking the Nature of Dust in the Diffuse ISM

Brandon Hensley
Thursday, September 28 IT

Department of Physics, Princeton University

Interstellar dust has long been modeled with separate silicate and graphite/amorphous carbon components. In this talk, I will argue that initially distinct populations of stardust get rapidly homogenized in the ISM into a composite material ("astrodust"). I will show that the astrodust+PAH model is compatible with current observational constraints on dust extinction and emission in the diffuse ISM, and that it provides a more natural explanation for the observed polarized emission than do two-component models.

Predicting the dust condensation sequence from a bottom-up perspective

David Gobrecht
Thursday, September 28 **CT**

University of Gothenburg

Classical condensation sequences rely on chemical and thermal equilibrium conditions that are typically derived from crystalline bulk material in a top-down manner. However, many astrophysical environments that show active signatures of dust formation are highly dynamical. Therefore, a non-equilibrium (i.e. kinetic), bottom-up treatment represents a more realistic description of dust grain nucleation and growth. In this talk I will present and review the latest results on accurate quantum-chemical calculations of (sub-)nanometer sized clusters including alumina (Al2O3), titania (TiO2) and vanadia (V2O5), and mixed metal oxides spinel (MgAl2O4), krotite (CaAl2O4) and magnesium-rich silicates (MgSiO3, Mg2SiO4). Based on the most favourable cluster structures and their thermochemical properties we derive a bottom-up obtained condensation sequence that depends on particle size, temperature and pressure. Moreover, we examine chemical-kinetic routes towards the formation of the corresponding monomers and dimers to determine their time-dependent abundances in dynamical physico-chemical outflow models. Combining the abundances with the derived spectral fingerprints of the clusters allows us to compare our synthetic model spectra with the most recent JWST observations.

Using JWST Photometry to Determine What Sets the PAH Distribution in Nearby Galaxies

Jessica Sutter

Thursday, September 28 **CT**

University of California [San Diego]

JWST provides an exciting new opportunity to study dust in nearby galaxies. The high-resolution of the MIRI and NIRCam photometry allow us to map the emission of polycyclic aromatic hydrocarbons (PAHs) in exquisite detail. As the PAHs play an important role in regulating heating and electron density in the interstellar medium (ISM), the distribution and properties of the PAHs are essential components of a complete model of energy transport in the ISM. Thus, understanding how ISM phase, galaxy environment, and properties like galactic radius and metallicity affect the PAHs is a necessary step towards expanding our understanding of how these small dust grains impact their environments. In pursuit of these goals, we have developed a proxy for the PAH-fraction of dust content that we call RPAH based on combinations of the MIRI bands. RPAH is the ratio of sum of the PAH-tracing F770W and F1130W bands divided by the F2100W band, which traces larger dust grain emission. To verify the utility of RPAH, we present comparisons between RPAH and qPAH determined through dust modeling. The strong correlation between these two properties suggests RPAH is a good photometric indicator of the PAH fraction. Based on these results, we present trends in RPAH with galactic radius, metallicity, gas content, and galaxy environment from the full set of galaxies in the Physics and High Angular resolution in Nearby GalaxieS (PHANGS) JWST sample (Cycle 1 Treasury Program 2107, PI Lee) . This sample contains star-forming galaxies spanning a range of morphological types with distances less than 20 Mpc. At these distances, JWST is able to resolve individual giant molecular clouds. Through comparisons to Halpha emission from MUSE, CO emission measured by ALMA, and HI data from the VLA, we can determine which ISM phases produce a majority of the PAH emission and how this varies between the galaxies in our sample. We can further determine how the PAHs vary outside of HII regions, where hard radiation destroys these small grains. The observed trends have implications for where we expect PAHs to play a prominent role in heating the ISM, and where these small dust grains are being destroyed by hard radiation fields.

Dust growth in high-redshift galaxies and its impact on the grain size distribution

Hiroyuki Hirashita
Thursday, September 28 **IT**

Academia Sinica

Dust can grow by the accretion of gas-phase metals in the interstellar medium. This process is proposed to be important to account for the dust abundance in high-redshift galaxies. Accretion also affects the grain size distribution, which influences the dust extinction properties. Thus, we construct an evolution model of grain size distribution in a galaxy by considering interstellar processing in addition to stellar dust production. We find that dust growth by accretion has a large impact on the grain size distribution in such a way that the abundance of small grains increases dramatically. This affects the extinction curve, and opens a possibility of discriminating the dust sources by observing dust extinction at various wavelengths. We also consider another dust growth mechanism, coagulation, which determines the maximum grain radius, and suggest that submillimeter galaxies could potentially be used as laboratories of dust coagulation. We finally introduce some recent numerical efforts for hydrodynamic simulations and radiative transfer calculations, and other extended applications for the CO-to-H2 conversion factor and PAH abundances.

Observational constrains on dust grain alignment: from protostellar cores to PDRs

Valentin Le Gouellec
Thursday, September 28 **CT**

NASA Ames Research Center

The linear polarization of thermal dust emission provides a powerful tool to probe interstellar and circumstellar magnetic fields, because aspherical grains tend to align themselves with magnetic fields lines. However, while the Radiative Alignment Torque (RAT) theory provides a quantitative framework for the understanding of this phenomenon, some aspects of this grain alignment mechanism still needs to be quantitatively tested. One such aspect is the possibility that the reference direction for the alignment may change from the magnetic field ("B-RAT") to the radiation field k-vector ("k-RAT") in areas of strong radiation fields, such as irradiated outflow cavity walls toward protostellar cores, or regions affected by massive star formations feedback mechanisms. Another aspect is the predictions of the RAT theory concerning the evolution of dust grains in the ISM, i.e., constraining the alignment of large grains is enabled in dense environment, and the rotational disruption of grains in irradiated regions. We will present several results obtained with observational and radiative transfer modeling studies toward protostellar cores and PDRs, using ALMA and SOFIA dust polarization observations, respectively. While the polarized dust emission seemed to be explained with some degree of dust growth and grain super-paramagnetism in embedded protostars, the dust polarization observed in PDRs tend to discard the k-RAT mechanism. In both cases, rotational disruption is predicted to be efficient toward the most irradiated and less dense regions, but further observational probes shall further constrain this grain disruption mechanism.

Observational evidence of morphological quenching in dusty elliptical galaxies

Aleksandra Leśniewska
Thursday, September 28 **CT**

Astronomical Observatory Institute, Faculty of Physics, Adam Mickiewicz University
Dark Cosmology Centre

The mechanism by which galaxies stop forming stars and get rid of their interstellar medium (ISM) remains elusive. I will present analysis and results obtained on a sample of more than two thousand elliptical galaxies in which dust emission has been detected. This is the largest sample of such galaxies ever analysed. One of the main result is the timescale for removal of dust in these galaxies and its dependency on physical or environmental properties. This timescale does not depend on environment, stellar mass or redshift. Another interesting result is a departure of dusty elliptical galaxies from the star formation rate vs. dust mass relation. This is caused by the star-formation rates declining faster than the dust masses and indicates that there exists an internal mechanism, which affects star formation, but leaves the ISM intact. Morphological quenching together with ionisation or outflows caused by older stellar populations (supernova type Ia or planetary nebulae) are consistent with these observations.

Rise and Fall of Anomalous Microwave Emission in Extragalactic Star Forming Regions

Ilsang Yoon
Thursday, September 28 **CT**

National Radio Astronomy Observatory

Anomalous Microwave Emission (AME) is a potential contributor to the radio spectral energy distribution (SED) in the frequency range that we believe is dominated by free-free emission and thermal dust emission. Although detection of AME from extragalactic star-forming regions is rare compared to the situation in our own galaxy, it is important to understand why extragalactic AME is rarely observed and how AME will impact the radio SED when observing galaxies in radio for a wide range of redshift using future radio telescopes (ngVLA and SKA). In this talk, I will introduce my recent work based on the investigation of AME emissivity from a massive star-forming region with a strong radiation field and shockwave propagating into the magnetized ISM. Based on recent studies of grain disruption due to centrifugal force by radiative and mechanical torque, I will illustrate how AME can be suppressed relative to free-free and thermal dust emission. I will also discuss how AME flux from extragalactic star-forming regions will change as galaxies are placed at higher redshifts.

Friday, 29th September, 2023

Dust destruction in supernova remnants

Elisabetta Micelotta
Friday, September 29

IT

Nanoform
University of Helsinki

Dust processing and destruction in supernova remnants is a topic of active research. Supernovae are efficient dust factories, as predicted for a long time by theoretical models and recently confirmed by observations. In particular, they represent the major potential suppliers of dust in the early Universe, due to the rapid evolution of their stellar progenitors combined with their efficiency in condensing refractory elements from the gas phase into dust grains. However, not all the supernova-generated dust is able to be expelled from the remnants and reach the interstellar medium. Dust must survive a perilous journey from the cavity where it is formed and initially resides. The pressure of the circumstellar material shocked by the expanding supernova blast wave generates a high velocity reverse shock which propagates across the remnant processing the freshly formed dust. The result of such processing depends on the properties of both dust grains and the environment where they reside, ranging from erosion to complete destruction. In this review, I will present the state of the art about dust destruction in supernova remnants, summarizing theoretical results and observational findings.

The Disappearing Act: Exploring the PAH Deficit at Low Metallicities

Elizabeth Tarantino
Friday, September 29

CT

Space Telescope Science Institute

In typical star-forming galaxies, the mid-infrared spectrum is dominated by emission from Polycyclic Aromatic Hydrocarbons (PAHs), the smallest dust grains found in the interstellar medium. However, in regions with low metallicities, the fraction of PAHs in the interstellar medium undergoes a significant decline. The underlying cause for this deficit remains unknown with several possible suggested explanations. One possibility is that the higher ultraviolet radiation fields common in low metallicity galaxies may more readily destroy the PAHs. Alternatively, PAH growth in the ISM may be inhibited in metal poor systems because of the lack of available carbon for formation and lower gas densities. PAHs can be used as a tracer of star formation rate and molecular gas, although their sensitivity to metallicity makes it extremely important to understand the effect of environment on their abundance. In this talk, I will provide an overview of previous attempts aimed at detecting PAHs in low metallicity environments and explore the proposed explanations for the PAH deficit. I will also present on-going analysis of new JWST imaging of the 3.3, 7.7, and 11.3 PAH features in two nearby, low metallicity galaxies Sextans A (7% solar metallicity) and IC 1613 (10% solar in O; 20% solar in Fe). These deep JWST observations of Sextans A and IC 1613 will provide valuable insights into the variations of PAH abundance in different environments, allowing us to better constrain the mechanisms responsible for their formation, destruction, and excitation.

Empirical constraints on dust destruction in supernova remnants

Felix Priestley

Friday, September 29 **CT**

Cardiff University

One of the key processes removing dust from the interstellar medium is the destruction of grains in shockwaves driven by supernovae (SNe). Existing theoretical models predict that each SN can 'clear' dust from roughly 1000 Msun of the interstellar medium (ISM), thus destroying 10 Msun of dust for a Milky Way gas-to-dust ratio of 100. However, these models typically assume an ISM with a uniform density of 1 cm-3, rather than a realistic multiphase structure, and rely on poorly-constrained dust physics such as grain shattering. I test the accuracy of these simulations by determining the distribution of the dust mass in a sample of Galactic supernova remnants between the cold (<1000 K) and hot (10^6 K) phases of swept-up ISM, and between large and small grain sizes. Contrary to model predictions, for all objects the vast majority (>90%) of the swept-up dust mass is located in the cold phase, and the grain size distribution in the hot phase is inconsistent with that expected from shattering. If shattering is inefficient, and most of the dust is not exposed to the high-temperature shocked gas, dust destruction rates are likely to be far lower than commonly-adopted theoretical values would suggest. I argue that this reduction in destruction efficiency is necessary in order to explain the depletion patterns of elements in the diffuse ISM, which are difficult to reconcile with rapid destruction of dust by SNe.

Interstellar carbonaceous dust erosion induced by X-rays irradiation of water ice in star-forming Regions

Ko-Ju Chuang

Friday, September 29 **CT**

Leiden Observatory

Interstellar dust grains play an essential role in enriching molecular complexity by providing catalytical surfaces to allow atomic or simple species to accrete, meet, and react. Astronomical observations using ground and spaceborne instruments (Spitzer, Herschel, and more recently, JWST) have revealed the great details of the interstellar ice composition, mainly constituting H2O, CO, and CO2. The physicochemical interactions between the above ice and dust surfaces and icy dust morphology remain unclear due to limited experimental work. This study aims to provide a better understanding of the possible ice-dust reactions using selectively isotope-labeled oxygen/carbon species. Ultrahigh vacuum experiments were performed to study the X-ray irradiation of interstellar ice analog on sub-micrometer thick C dust at $\sim$13 K, mimicking the proto-planetary midplane conditions. H2O and O2 ice were deposited on the pre-synthesized amorphous C dust and exposed to soft X-ray photons (250–1250 eV). Kinetic analysis of the reaction products was performed using Fourier-transform infrared spectroscopy. Field emission scanning electron microscopy was used to monitor the morphological changes of (non-)eroded carbon samples. Experimental results show that the X-ray processing of the ice-dust interface leads to C dust erosion accompanied by the formation of CO2 and CO. The erosion process is confirmed due to oxygen addition to grain surfaces forming carbonyl groups as an intermediate product. The yields of CO and CO2 were found to be dependent on the thickness of the carbon layer, implying the studied dust erosion might affect the chemical composition in protoplanetary disks where X-ray is the dominant energetic source and icy dust starts coagulation.

Radiative Torque Disruption and Implications

Le Ngoc Tram

Friday, September 29 **IT**

Max Planck Institute for Radio Astronomy

The interaction of the radiation field can cause large dust grains to spin suprathermal. This suprathermal rotation could induce rotational disruption of large grains into small fragments, which determines the upper cutoff of the grain size distribution (GSD) and causes the variation of GSD with the radiation field. This new mechanism is named after Radiative Torque Disruption (RAT-D). The modified GSD by RAT-D, in turn, affects dust optical-UV extinction, thermal emission from infrared to radio wavelengths, and polarization. This talk will review the RAT-D mechanism and its implications, primarily focusing on dust polarization studies.

From total destruction to complete survival: Dust in supernova remnants at different evolutionary stages

Florian Kirchschlager

Friday, September 29 **CT**

Ghent University

The expanding ejecta of supernova remnants (SNR) forms dust in over-dense clumps of gas. Before the dust can be expelled into the interstellar medium and contribute to the interstellar dust budget, it has to survive the reverse shock that is generated through the interaction of the preceding supernova blast wave with the surrounding medium. The conditions at which the reverse shock hits the clumps change with remnant age and define the dust survival rate. To study the destruction in the SNR Cassiopeia A, we conducted magnetohydrodynamical simulations of the evolution of a supernova blast wave and of the reverse shock. In a second step we used these evolving conditions to model clumps that are disrupted by the reverse shock at different remnant ages. Finally, we computed the amount of dust that is destroyed by the impact of the reverse shock. We find that most of the dust in the SNR is hit by the reverse shock within the first 200 yr after the SN explosion. While the dust destruction at this early phase is almost complete, we expect greater dust survival rates at later times and almost total survival at ages beyond 1000 yr.

Posters abstracts

1 - ALMA observations of Titanium and Aluminium bearing species in Mira

Maryam Saberi

University of Oslo

Asymptotic giant branch (AGB) stars stand out as prominent contributors to the production of dust within our Galaxy. However, the intricate process of inorganic dust grain condensation in the outflows of AGB stars remains uncertain. Theoretical investigations, rooted in chemical and thermal equilibrium, have pinpointed aluminium oxides, titanium oxides, and silicon oxides as the primary contenders for serving as the nuclei around which dust particles coalesce in M-type AGB stars. Nevertheless, the mechanisms responsible for the remarkably efficient coagulation of molecules into dust grains remain poorly understood. In this study, our objective is to probe the formation of dust surrounding the nearby M-type AGB star, Mira, using finely resolved observations from the Atacama Large Millimeter/submillimeter Array (ALMA) across Bands 6, 7, and 8. Our analysis has successfully identified multiple spectral lines, including 46TiO, 48TiO, 49TiO, 50TiO, 46TiO2, 47TiO2, 48TiO2, 49TiO2, 50TiO2, AlO, AlCl, AlF, SO2, SO, SO2, SiO, and SiS. We have employed the rotational diagram method to meticulously estimate the column density and abundance of the majority of these detected species through multiple observations. We aim to provide a more precise characterization of the aluminum and titanium budgets within the inner outflow region of Mira, with the ultimate goal of shedding light on the intricate processes governing dust formation in Mira's inner outflow.

2 - Alternative Dust Grain Formation: Pathways of Formation from Alane and Ammonia

C. Zachary Palmer

The University of Mississippi

Aluminum's highly refractory nature grants it easier aggregation into bulk solid-phase grains suggesting a large contribution to the dust grain formation present in the interstellar and circumstellar medium (ISM and CSM). For years, alumina and other [Al, O] complexes have dominated the field of astrochemical and astrophysical research into the origins of interstellar and circumstellar dust grains. However, previous studies indicate that aluminum may also assist in the formation of these dust grains in the form of aluminum nitride (AlN) clusters opening an avenue of currently underexplored research. The present study provides a novel reaction pathway and rovibrational spectroscopic data, where applicable, for [Al, N] clusters that may be present in the interstellar medium. This is done through the use of quartic force fields with assistance from DFT methods to provide the spectroscopic data included herein. Such data will assist current, available technologies, like the Atacama Large Millimeter/submillimeter Array or the James Webb Space Telescope, to assist in further understanding dust grain chemistry in the ISM and CSM.

3 - Collision Induced Dissociation of Water Pyrene Molecular Clusters

Arya M Nair

IRAP, Université de Toulouse

In photodissociation regions (PDRs) associated with star formation, matter composed of gas and tiny dust particles is in strong interaction with the ultraviolet radiation from young stars. From the analysis of observations of infrared space missions such as Spitzer, it is proposed that isolated polycyclic aromatic hydrocarbons (PAHs) are produced from the destruction of carbonaceous very small grains (C-VSGs) at edge of PDRs [1]. Clusters of PAHs have been proposed as models for these C-VSGs [2]. They come from the inner part of interstellar clouds where models predicts transition from gaseous to icy water [3]. They are therefore expected to interact with molecules such as water, a process that can be also of special interest in the models of planet-forming discs [4]. This motivates our experimental study on water-PAH molecular clusters. Mixed pyrene (C16H10, Py) - water cationic clusters are produced in a gas aggregation source cooled at liquid nitrogen temperature [5] prior to thermalization at 25K. The observed clusters are either in protonated (predominant), native or dehydrogenated forms. Collision induced dissociation (CID) is used in order to study the energetics of the produced species and get insights into their structure. The species of interest are mass selected and undergo collisions with inert gases at varying kinetic energy of the ions. The products are analysed by time-of-fight mass spectrometry and the absolute fragmentation cross sections are recorded. CID experiments were performed on (Py)m(H2O)nH+ (m= 1 to 3, n= 1 to 10) and (Py)1(D2O)nD+ (n= 1 to 9) at 7.5 eV centre-of-mass collision energy. Both water loss and pyrene loss channels are observed. For (Py)1(D2O)nD+, we could also observe contribution from H-D exchange. Complementary Threshold CID (TCID) measurements were performed for complexes made of one pyrene molecule (protonated and dehydrogenated) and 1 to 5 water molecules. The variation of the dissociation threshold with the species gives us extra information about the structure and energetics of these species. Finally, calculations were performed to obtain structural and energetic data and support the analysis of the experimental results in terms of proton localization and dissociation energies. The results obtained so far will be presented and discussed. [1] P. Pilleri et al, A.&A. 542, A69(2012). [2] M. Rapacioli et al, A.&A. 429, 193–204(2005). [3] D. Hollenbach et al, Astrophys. J. 690, 1497(2009). [4] B. Ercolano et al, MNRAS 512, 430-438(2022). [5] I. Braud et al, Rev. Sci. Instrum. 88, 043102(2017).

4 - DEATHSTAR – Accurate mass-loss-rate estimates for AGB stars

Miora Andriantsaralaza

Uppsala Universitet

Mass loss by a stellar wind is a decisive process for late stellar evolution. The mass loss during the Asymptotic Giant Branch (AGB) is thought to be dust-driven, as radiation pressure on dust grains pushes the grains and the surrounding gas out of the stellar gravitational field due to gas and dust momentum exchange. A vast amount of elements formed on the AGB are thus ejected into the interstellar medium via their massive dusty outflows. Accurate characterization of this mass loss phenomenon is, therefore, key to advancing our comprehension of stellar evolution and the chemical enrichment of the Galaxy. The DEATHSTAR project aims to improve the accuracy of measurements of stellar wind parameters of AGB stars by using enhanced distance estimates and new interferometric observations to constrain radiative transfer models of dust and gas emissions. In this poster, I will present the current results from the modelling of the spectral energy distributions of a sample of 27 southern nearby carbon stars in the DEATHSTAR sample. The obtained radiation field and dust properties will then be used as inputs for CO line emission radiative transfer modelling to determine their mass loss rates.

5 - Disentangling galaxy and dust evolution mechanisms through chemical abundances

Stefan van der Giessen

Ghent University
Universidad de Granada

It is a difficult task to constrain the origin of the amount of stars, gas, and dust within a galaxy, as several mechanisms link their evolution. The total gas mass surface density or the molecular gas mass surface density regulates the star-formation rate through the Schmidt-Kennicutt law. The star-formation rate determines the dust-formation rate from asymptotic giant branch stars and supernovae, present in regions of relatively high molecular gas mass surface density, where dust also accretes gas-phase metals on dust grains, the so-called grain growth. Star-formation rate also drives the supernovae rate. Supernovae create energetic shocks that destroy dust grains and can efficiently push the gas outside the galaxy through gas outflows. As all these mechanisms act at different time scales, the amount of dust in a galaxy is directly linked to the star formation history and how much galaxy material is expelled in the circumgalactic medium by the powerful galactic outflows. We can potentially disentangle the evolution effects by adding information on the chemical abundances of several elements. Oxygen primarily forms in high-mass stars and gets released by supernovae, whereas nitrogen forms in low and intermediate-mass stars and requires oxygen to enhance the formation. The stellar lifetimes of the oxygen and nitrogen sources differ, making the relative ratio a good tracer for the potential shape of the star-formation history. The goal of the talk is to showcase spatially resolved maps of the stellar mass, gas mass, and dust mass surface density for local spiral galaxies NGC628, M101, M33, and NGC300 to motivate the use of a chemical and dust evolution code for disentangling the different evolution mechanisms within these galaxies. This poster will highlight radial profiles corresponding to these maps and how differences in the dust-to-stellar mass ratio and the dust-to-metal ratio can be explained by showing how these ratios vary with oxygen abundance and the nitrogen-to-oxygen abundance ratio.

6 - Dust Coagulation in Oxygen-rich Circumstellar Outflows

Joseph Nuth

NASA Goddard Space Flight Center

Inefficient growth of SiO molecules on (SiO)x dust grains prolongs the period of maximum dust nucleation in circumstellar outflows resulting in a several order-of-magnitude increase in dust density near the star. This increase in dust density powers dust coagulation and results in the formation of fractal aggregates that are extremely efficient per unit mass in coupling to both the stellar radiation field and the ambient gas. Kimura et al. (2022, ApJL, 934, L10) showed that for SiO molecules colliding with (SiO)x clusters, the growth efficiency is approximately 0.01; e.g., only 1 in 100 molecules that hit a growing cluster are incorporated into the grain. During grain formation SiO is depleted both by the formation of stable dust nuclei and by the growth of these grains. Inefficient dust growth slows the depletion of SiO molecules into growing grains and results in the production of many orders of magnitude more stable dust nuclei that also grow more slowly. A decrease in the average final grain radius from 0.5 microns to about 5 nm for the same fractional SiO depletion, increases the grain number density by a factor of a million. Since the coagulation rate increases with the square of the primary grain number density, the coagulation rate of these smaller grains is a factor of a trillion higher than for larger dust grains. This has some interesting consequences. First, circumstellar outflows around oxygen-rich stars will produce copious quantities of fractal dust grains. These grains have a very high surface to volume (or mass) ratio and will be very efficient catalysts for chemistry in circumstellar shells. Second, while individual nanometer-scale dust grains are much less efficient (per grain) in absorbing or scattering photospheric emission from an AGB star, the much greater number density of fractal aggregates of these smaller grains more than compensates for their inefficiency such that, per unit condensed silicate mass, fractal dust particles are more efficient “sails” powering AGB outflows. As fractal aggregates become larger, they are more efficient radiators, potentially requiring modifications to standard models of the spectral energy distributions of AGB stars.

7 - Dust content in a $z\sim2$ quiescent galaxy

Minju Lee

DAWN/DTU space

This talk presents our recent study of a quiescent galaxy at $z\sim2$ based on deep ALMA Band 4 observations. We discovered a dust-rich, massive (Mstar $\sim$ 1e11 Msun) quiescent galaxy at $z\sim2$ that exhibits a high dust-to-stellar mass ratio of 0.3%. This is one of the highest dust content measured in quiescent galaxies at high redshift. Based on the spectral energy distribution modeling, the talk will demonstrate how it compares with the latest measurements in the local and distant universe and discuss the potential origin(s) of the observed dust in the galaxy, and challenges given the current dust measurements.

Dust depletion of metals from from the Milky Way to z$\sim$6

Christina Konstantopoulou

University of Geneva

The cycle of metals between dust and gas plays a fundamental role in the chemical enrichment of the ISM. Metals are missing from the observable ISM gas phase because they are instead incorporated into dust grains, an effect we call dust depletion. This effect alters the observed chemical abundances, which can be inferred through absorption-line spectroscopy. Characterizing the dust depletion of metals both in the local and distant Universe is important to investigate the evolution and origin of metals and dust through cosmic time. The fraction of metals in dust can be described by the dust-to-metal ratio (DTM) and the dust content by the dust-to-gas ratio (DTG). These properties can give us clues about the production and destruction mechanisms of dust and how it evolves with metallicity and over cosmic time. I will present my recent results on characterizing the dust depletion of several metals using relative abundances in different galactic environments, including the Milky Way, the Magellanic Clouds and damped Lyman-alpha absorbers (DLAs) towards quasars (QSOs) and towards gamma-ray bursts (GRBs). Our inferred dust depletion measurements are then used to estimate the DTM, DTG and the dust composition in the ISM in these different galactic environments. These results have implications on the origin of cosmic dust and the dominant processes of dust production.

9 - Dust grain size evolution in local galaxies as a key to understand galaxy evolution

Monica Relano

Ghent University

The physical properties of the dust grains are directly linked to those of the ISM where it is located. Dust is created in LIMS (low-intermediate-mass stars) and SNe (supernovae) but it is also affected by other mechanisms. Dust grains can be destroyed or suffer erosion via sputtering in SN shocks, grain-grain collisions can either result in grain coagulation, producing a larger fraction of big grains, or shattering that acts as a source of small grains. Dust grains can also grow by accreting metals from the gas phase onto their surfaces, and thus increasing the total dust mass of the system. Due to all these processes, the dust grain size distribution in a galaxy evolves with time and the relative abundance of the different dust grain types gives very useful information to study the dust evolution, which in turn is directly linked to the evolution of galaxies. In the recent years an impressive amount of work regarding dust evolution has been done by linking the physics of dust to models of chemical evolution of galaxies (De Vis+21,De Looze+20,Galliano+21). A step forward is to incorporate how the different dust grains are modified along the dust life in the ISM (e.g.Hirashita 15). Hydrodynamical simulations of individual galaxies and cosmological volumes (Granato+21,Aoyama+20), and also semi-analytical models (Triani+20,Vijayan+19,Popping+17) have included the evolution of the different dust grains and predict how the small-to-large grain ratio varies along the evolutionary time. In this talk we present a systematic analysis of the observed spectral energy distribution of a large sample of galaxies in the local Universe to derive the relative mass fraction between small and large dust grains. Simulations reproduce relatively well the observations except for the high-stellar mass regime where dust masses tend to be overestimated. We find that 45% of the galaxies in our sample exhibit a high small-to-large grain ratio. For these galaxies having also high-molecular gas mass fractions and metallicities, coagulation is not an important mechanism affecting the dust evolution. We provide an explanation for these galaxies based on metal diffusion. We also present a comparison of the small-to-large grain ratio derived at spatially resolved scales for a small sample of nearby galaxies with simulations of individual galaxies including grain size evolution. With these comparisons, we reinforce the use of the small-to-large grain mass ratio to study the relative importance of the different mechanisms in the dust life cycle and galaxy evolution.

10 - Dust modelling in L-Galaxies semi-analytical model of galaxy formation

Aswin P Vijayan

Cosmic Dawn Center, DTU Space

Hydrodynamical simulations of galaxies provide a way to explore the spatial distribution of star, gas (or dust) within a galaxy. However, they are expensive and time consuming to run and thus exploration of physical or observed parameter spaces is difficult. On the other hand semi-analytical models usually run on top of dark matter only simulations and can explore parameter spaces quickly and cheaply. In this talk, I will introduce the L-Galaxies semi-analytical model and detail our implement model for dust production and destruction. The model includes dust production from stars and grain growth in molecular clouds, and dust destruction from supernovae shocks. Novel features in this work compared to similar efforts are more accurate consideration of the impact of molecular cloud chemistry on grain growth in dense molecular clouds, and incorporating information on dust depletion fractions. The former results in the diverse distribution of the dust-to-metal ratio seen in the high-redshift Universe in the model and the latter to the non-saturation of metals onto dust. The model also predicts grain growth to be the significant dust production mechanism for redshift less than 8. We see that the dust-to-metal ratio in galaxies can be approximated by a fitting function that depends on the stellar ages and metallicities. I will conclude with how the results from the model have been successfully used to translate galaxies from hydrodynamical simulations of the early Universe into the observer space. If time permits I will also detail a work in progress on the exploration of observed parameter space using the latest L-Galaxies model. In this model galaxies are resolved using concentric rings and enabling spatial studies in semi-analytical models.

11 - Dust Properties and Extinction Curves in the Magellanic Clouds, M31, and M33

Petia Yanchulova Merica-Jones

Space Telescope Science Institute

We present results for dust grain properties in nearby galaxies using two complementary methods. First we use spatially-resolved HST multiband photometric observations of millions of stars from two large photometric surveys in the Magellanic Clouds to understand how the interstellar medium (ISM) impacts dust properties. Our analysis relies on an open-source Bayesian tool which models the photometric spectral energy distribution of individual stars to derive their dust extinction (A(V), R(V), and fA) and stellar properties (Teff, mass, surface gravity, luminosity, and metallicity) in addition to fitting the distance to each source. With these results we generate high-resolution 3D maps in key regions of each galaxy and compare these maps to the distribution of ISM tracers (the HI column density, CO, the dust mass from IR emission, and the PAH fraction). Our photometry-based approach has the potential to answer questions about the nature of dust grain features (i.e., the origin of the 2175A bump) and to independently calibrate dust grain models. Additionally, we study the wavelength dependence of dust extinction and the properties of dust grains in diverse interstellar environments in M31 and M33. We use low-resolution HST UV spectra of a sample of reddened OB stars obtained by the Space Telescope Imaging Spectrograph together with near-IR to near-UV HST multiband photometric data to construct the extinction curves for about fifteen sightlines. In addition to modeling stellar parameters (Teff, log(g), and metallicity), we constrain A(V), R(V) and the Fitzpatrick and Massa (1990) parameters describing the shape of the extinction curve. We also make a direct measurement of N(HI) using Lyman-alpha absorption lines yielding the dust-to-gas ratio. These are the first measurements of the UV extinction curve in M33 which illuminate dust extinction properties in an environment probing a unique set of physical and chemical evolution properties among Local Group disk galaxies.

12 - Dust surface chemistry in the AB Aur protoplanetary disk: observations and models

Pablo Riviere

Observatorio Astronómico Nacional

Chemical reactions in the surface of dust grains are a key element of astrochemical networks. At the high extinction levels of cores in molecular clouds, where temperatures are low, most of the chemical reactions happen on the surface of grains. Furthermore, organic molecules with six or more atoms, the so-called Complex Organic Molecules, are formed in the surface of dust grains, via the diffusion and reaction of radicals produced by the photodissociation of stable molecules. Thus, understanding surface chemistry reactions is key for the study of star and planet formation, as well as for the emergence of life. Planets are formed in protoplanetary disks surrounding young stars. These disks are made of dust and gas, and a mixture of gas-gas reactions and surface chemistry reactions shapes their chemical evolution, depending on the height above the mid-plane. In the mid-plane, where planet formation takes place, the physical conditions are similar to those of dark cores in molecular clouds, and thus surface reactions play a major role. The dust grains and gas species present in these disks are inherited from the natal cloud, but they are also subject to an uncertain level of reprocessing. Understanding to what extent the composition of the ice surface of dust grains is inherited is a key element for the study of protoplanetary disks. AB Aur is a well-known A0 star in Taurus-Auriga that host a transitional disk where signs of ongoing planet formation have been detected. Such signs include a dust trap, a large dust cavity, and twisted isophotes in the first-moment maps of molecular species. We are conducting a detailed study of AB Aur's protoplanetary disk by means of single-dish and interferometric radio observations, combined with ancillary and archival data at different wavelengths, as well as with radiative transfer, magneto-hydrodynamical, and astrochemical models. We will present the results of our studies of continuum emission used to characterize the dust physical properties and composition in AB Aur, and discuss them in the context of astrochemical networks and surface chemistry reactions, linking the spatial distribution of chemical species with that of the different grain populations.

13 - Dusty feedback from massive stars

Elvire De Beck

Chalmers University of Technology

Massive stars efficiently lose mass at all stages of their evolution, including the red supergiant (RSG) phase. Since RSGs are progenitors to type II-P supernovae, how and how much mass is lost significantly influences the supernova explosion, its light curve, the remnant, and the resultant elemental and dusty yields. The mass-loss process during the RSG phase is, however, still poorly constrained.

We present recent observational results on NML Cyg, a nearby RSG. High-angular resolution observations at submillimetre wavelengths using the NOEMA interferometer reveal a high degree of complexity in its circumstellar environment. In the measured continuum emission, the star is completely outshone by two bodies of dust, which likely are conglomerations of multiple smaller clumps within a distance of roughly 1000 AU from the star. We derive temperatures of 250K and 450K and a total dust mass in these clumps of 0.002 solar masses. The observations also show a much larger molecular envelope than previously assumed was possible considering the nearby Cyg OB2 association. In addition, the measured molecular emission, from e.g. CO, SO, SO2, and H2S, shows clumps, arcs and shells tracing multiple outflow components linked to highly episodic and anisotropic mass loss.

14 - Experimental diffusion of water through porous amorphous carbon dust analogues

Romain Basalgète

Laboratory Astrophysics Group of the Max Planck Institute for Astronomy at the Friedrich Schiller University Jena, Institute of Solid State Physics, Jena

Interstellar dust plays a crucial role in the chemistry of the interstellar medium by providing catalytic surfaces for the formation of molecules. The surface reactions involved are of primary importance since they have explained a variety of gas phase abundances in the interstellar medium. These reactions depend primarily on how the atoms and molecules diffuse on the surface and/or through the dust grains. To date, laboratory experiments have focused on the diffusion of volatiles (CO, NH3, CO2, ...) in water ice (e.g. [1]) and very little is known on the influence of the dust grains on such processes. Gas transport through porous media analogous to interstellar dust is also an important topic in cometary science [2]. Interstellar dust analogues synthesized in the laboratory [3] offer a unique opportunity to better understand the diffusion processes in dust grains. Here we propose to study such processes for water, which is a major component of interstellar and cometary ices. Thin layers of water ice were deposited on a cold substrate and covered by carbon or silicate dust grains produced by pulsed laser ablation of a solid target in a quenching gas atmosphere. The diffusion of water through the dust layers was activated by heating up the substrate. Isothermal modifications of the infrared bands of the water over time enabled us to quantify the diffusion process and to measure physical parameters of primary importance for astrochemical models, such as the diffusivity. In this context, I will present the main findings of the studies and I will discuss their astrophysical implications.
[1] Mispelaer et al., Diffusion measurements of CO, HNCO, H2CO, and NH3 in amorphous water ice, A&A, 555, A13 (2013) [2] Skorov et al., Activity of comets: Gas transport in the near-surface porous layers of a cometary nucleus, Icarus, 212, 867-876 (2011) [3] Jäger et al., Spectral properties of gas-phase condensed fullerene-like carbon nanoparticles from far-ultraviolet to infrared wavelengths, The Astrophysical Journal, 689:249-259 (2008)

15 - Generating candidates in global optimization algorithms using complementary energy landscapes

Andreas Møller Slavensky

Center for Interstellar Catalysis, Aarhus University

Global optimization (GO) algorithms, which attempt to obtain the global minimum energy (GM) structure of a given stoichiometry, can be used to find low-energy clusters. Global optimization of atomistic structure relies on the generation of new candidate structures in order to drive the exploration of the potential energy surface (PES) in search for the GM structure. In this work, we discuss a type of structure generation, which locally optimizes structures in complementary energy (CE) landscapes. These landscapes are formulated temporarily during the searches as simple machine learning potentials (MLPs) using local atomistic environments. The CE landscapes are deliberately incomplete MLPs in order to make them smooth, having only few local minima. This means that local optimization in the CE landscapes may facilitate identification of new funnels in the true PES. We test their influence on global optimization of an olivine (Mg2SiO4)4 cluster for which we report a new highly symmetric GM structure.

16 - High Resolution Spectra of the Galactic Binary Pulsar 4U 1907+09

Jun Yang

Massachusetts Institute of Technology

The accreting pulsar 4U1907-09 is one of 35 high-mass X-ray binaries with known high magnetic field strengths. A detected cyclotron resonance scattering feature at 19 keV leads to a field strength of 2E12 G. The system consists of a slowly-rotating (440 s) X-ray pulsar accreting from the stellar wind of an O8/9 supergiant. The X-ray pulsar is in a close (8.37 d) elliptical orbit (e $\sim$ 0.28) around its donor. We conducted an analysis of four High Energy Transmission Grating observations with the Chandra X-ray Observatory for a total of 140 ks and one NuSTAR observations for 78 ks, at different orbital phases, to probe the variation of the absorbing column around the orbit. We measure line fluorescence at Fe K and possibly Si K and other lower Z elements to study dense clumps in the wind of the pulsar's companion star. The details of the NuSTAR observation are used to determine the higher energy continuum beyond 10 keV.

17 - High-resolution view of the inner circumgalactic medium of NGC891

Ilse De Looze

Department of physics and astronomy, Ghent University

The baryonic cycling of the material pushed out of the galactic midplane by stellar and/or supernova feedback processes, and the fallback of cool circumgalactic gas onto the disk is uniquely observed in edge-on galaxies. As such, NGC 891 is a perfect target to study the life-cycle of baryonic material. Its virtually perfectly edge-on inclination (89.7 degrees) and closeness (9.6 Mpc), together with the sensitivity and resolution of JWST imaging instruments lets us probe faint structures in the circumgalactic medium down to $\sim$10 pc scales. We were able to confirm the presence of dust out to $\sim$5 kpc (S/N >= 3), forming a loop-like structure, tentatively suggesting the existence of a galactic fountain. Using unsharp masking techniques and Spitzer/IRAC 8 micron data, we investigate the connection of these filament-like structures to the disk, and their association to potential star forming regions, which could be the drivers of expelled interstellar material outside of the galaxy. We also track the distribution of small clumps, whose sizes range from 10 to 30 pc, suggesting the existence of small pockets of processed dust grains out in the CGM.

18 - Interstellar Dust Extinction from the Far-Ultraviolet to the Mid-Infrared

Karl Gordon

Space Telescope Science Institute
Ghent University

Dust extinction measurements provide important constraints on the size, composition, shape, and abundance of dust grains and an empirical model to account of the effects of extinction on astrophysical objects. For decades our understanding of dust grains was strongly biased by measurements in our Galaxy and the ultraviolet (UV). The UV bias is due to the extensive spectroscopic observations taken with the IUE satellite revealing the details of the 2175 A bump, far-UV rise, and underlying extinction continuum. I will discuss the results of a dedicated effort to expand our spectroscopic measurements of dust extinction to the far-UV, optical, near-infrared, and mid-infrared wavelength regimes. This work has revealed new optical extinction features, enabled the first combined combined study of UV and MIR extinction features, shown the possible presence of ice in the diffuse interstellar medium, and revealed an intriguing correlation between UV extinction and molecular hydrogen. Building on these works, a new R(V) dependent extinction relationship at spectroscopic resolution from 912 A to 32 microns has been determined. Finally, preliminary JWST extinction curves in the near- and mid-infrared will be shown.

19 - Magnetic field revealed by polarized dust emission in G28.34

Jihye Hwang

Korea Astronomy and Space Science Institute

Magnetic field plays an important role to support star-forming regions against gravitational collapse. However, in dense cores or clumps, gravity exceeds magnetic support and stars are formed. The correlation between magnetic field and core fragmentation is not fully understood. Magnetic field orientations, and relative energies of turbulence, gravity and magnetic field can affect the core fragmentation. We estimate magnetic field orientations and those energies in a massive cloud, G28.34 using JCMT and ALMA polarization data to show magnetic properties in a cloud and core scales. Magnetic field orientations in the cloud and core scales are roughly perpendicular to each other, which can result from the effect of outflow in the core scale. Magnetic field strength in the cloud scale is 1.3 mG which is comparable to that in the core scale of 1.6 mG. The relative importance between gravity and magnetic field can be expressed using the mass-to-flux ratio which is 0.3 in G28.34. It means the magnetic field is strong enough to support G28.34 against gravitational collapse. Magnetic field energy is one order of magnitude larger than gravitational and turbulent energies in the cloud scale of G28.34. From these results, in the cloud scale, the magnetic field is more dominant compared to turbulence and gravity. However, the magnetic field in the core scale is affected by outflows which can cause the core fragmentation in G28.34.

20 - Mapping the interstellar dust and ice with JWST

Burcu Günay (Karl Gordon)

Space Telescope Science Institute
Johns Hopkins University

In the interstellar medium (ISM), the refractory compounds form interstellar dust and volatile compounds form interstellar ices. Among the major heavy elements, carbon and oxygen are the most abundant in the solid phase in the ISM. The total chemical abundances observed in both the gas and solid phase in the ISM should agree with cosmic abundance estimates of the elements. However, in the ISM, carbon and oxygen depletion from the gas phase is not consistent with the proposed abundances in the solid particles. These have been referred to as the carbon crisis and the missing oxygen problem, respectively. Although, the cosmic abundances are still in debate, there is a need to measure the abundance of elements locked in the solid phase of ISM. For this purpose, there are some spectral features in the IR region that can be used. The 3.0-microns water ice O-H feature, the 3.4-microns aliphatic hydrocarbon C-H feature and the 9.8-microns silicate Si-O feature have particular importance as they are suitable for quantitative studies. It is possible to estimate abundance of elements from optical depth of the related absorption feature. Optical depths can be obtained by spectroscopic methods, but studying multiple sources over wide fields requires long observation time. Photometric measurements with narrow-band filters can be used to sample the spectrum. Photometric method can be applied to multiple sources in the field of view. We present a photometric method to measure the optical depth of the 3.0-microns water ice, the 3.4-microns aliphatic hydrocarbon and the 9.8-microns silicate feature, by using JWST. This method will permit us to map carbonaceous, siliceous dust and ice over wide fields. The resultant maps will reveal the abundance distribution of the major solid phase elements and the structure of the solid phase of the ISM.

21 - Mechanisms of SiO oxidation and dust formation

Stefan Andersson

University of Gothenburg

In order to elucidate the efficiency of the formation of silicate dust particles it is necessary to study various hypothesized reaction mechanisms in detail at the molecular level. We present calculations of reaction mechanisms and reaction kinetics of the initial stages of the oxidation of SiO and silicon oxide cluster growth. Molecular structures and energies were calculated using electronic structure theory, i.e., density functional theory and coupled cluster methods. Reaction rate coefficients were calculated using master-equation calculations based on calculated structures, energies and vibrational frequencies. The chemistry of a circumstellar environment of an oxygen-rich AGB star was simulated by introducing the calculated rate coeffcients into a chemical reaction network. The limited formation of larger silicon oxide species in the model seems to indicate that considering only silicon oxide molecules is not sufficient to initiate efficient formation of silicate dust particles.

22 - Modelling the cold dust in nearby spiral galaxies with radiative transfer

Angelos Nersesian

Ghent University

Cosmic dust grains are one of the fundamental ingredients of the interstellar medium (ISM). Despite of their limited contribution to the total mass budget, dust grains play a significant role in the physical and chemical evolution of galaxies. Over the past decade, our knowledge on the cosmic dust in nearby galaxies has increased substantially thanks to the availability of observational data from UV to far-infrared wavelengths. However, one part of the spectrum, the mm range, has largely remained unexplored. We aim to take advantage of the new, high-resolution data in the mm range observed with the NIKA2 instrument. Combining these new observational data with our radiative transfer framework, would allow us to accurately model the interplay between starlight and dust in a sizeable sample of spatially-resolved nearby galaxies. I will present the methodology of our dust radiative transfer modelling and its application to a small group of face-on spiral galaxies. I will highlight which modelling steps need to be improved, and how the new NIKA2 data would allow us to firmly characterize the physical properties of the very cold dust (<15K), as well as to quantify the importance of different emission mechanisms in the mm.

23 - Modelling the dust cycle in local discs: unveiling the contribution of dust processes at kpc scales

Marco Palla

Ghent University
INAF - OAS Bologna

In the literature, a large amount of work has been devoted to the study of the build-up of metals and dust in galaxies. However, most of these analyses are based on global galactic properties. Therefore, spatially resolved studies are crucial to provide more detailed information on the evolution processes affecting star forming galaxies. In this talk we will concentrate on the DustPedia M74 / NGC628 disc galaxy, one of the best examples for which spatially-resolved observations of fundamental physical quantities are available. These quantities have been used to build a multi-zone chemical and dust evolution model for this source, for which the star formation history parameters in each galactic zone are determined following a Bayesian approach, i.e. by performing a MCMC fitting on the stellar an gas density profiles for this galaxy. With these star formation histories, we then model dust evolution in different galactic regions by testing a very wide range of literature prescriptions about stardust production, dust growth within dense ISM and SN dust destruction. We find that by considering different functional forms for both the dust accretion timescale and the cleared dust mass per SN, we are able to account for the dust mass profiles observed in M74/NGC628. These different models envisage a different current balance between destruction and accretion, in that both an equilibrium and a dominion of accretion over destruction can equally reproduce the available constraints. This outlines the strong degeneracy between the sub-grid recipes currently adopted in the literature in shaping the interstellar dust content in galaxies and the need for much deeper investigation on the role of individual processes contributing to the dust cycle.

24 - A Novel sub-mm Galaxy Emission Line Survey - ANGELS

Tom Bakx

Chalmers University of Technology

ALMA has fundamentally improved the quality and resolution of studies of galaxies in the early Universe. Its spectroscopic capabilities reveal the properties of the gas inside and surrounding galaxies from low to very dense environments. However, often such observations require re-tuning, leading to overheads that fundamentally limit ALMA's spectroscopic capabilities to several tens of sources per project. Instead, I explore a method to use fixed spectral windows that include as many lines as possible. We successfully target 85 lines within just 6 hours of observation time across Bands 3 through 8; a five-time improvement compared to existing line surveys. This method can be extended to improve the science output of any future continuum snapshots of sources with known redshifts that could, for free, pick up additional lines.

25 - Plasma generation and characterization of ‘dense’ and ‘fluffy’ hydrocarbon cosmic dust analogs

Ramón J. Peláez

INSTITUTO DE ESTRUCTURA DE LA MATERIA (IEM-CSIC)

In this work, we present two different kind of hydrocarbon dust analogues produced with cold plasma in RF discharges. These two materials have been extensively analyzed in recent years by our group. We have studied their morphology, optical properties, and examined their behavior under realistic astrophysical conditions, including energetic irradiations and desorption of volatiles, among others. Inductive or capacitive RF discharges of reactive gases (CH4 or C2H2) are used to produce thin "dense” films (1 g/cm^3) or porous "fluffy" deposits (0.007 g/cm^3), respectively. Cross-section SEM images of thin films reveal a compact structure with minimal roughness, whereas the porous structures exhibit aggregates of nanoparticles with diameters around 100 nm. The optical indices at 632.8 nm are similar for both materials, with a value of n=1.7 and minimal absorption. The IR absorption spectra reveal the prominent band at 3.4 microns (CHx stretching), while the band structure at 6.2 microns (C=C stretching) varies depending on the material. The thin film is composed mainly of aliphatic compounds, whereas the porous structure exhibits a combination of aliphatic and aromatic compounds. In both cases, the IR absorption spectra confirm that these materials are suitable cosmic dust analogs. Destruction rates of the 3.4 microns band are estimated under UV and keV electron irradiations, simulating the effects of the interstellar UV field or cosmic rays. Preliminary results on both materials reveal that cosmic rays alone cannot explain the observed disappearance of the 3.4 microns band in dense interstellar clouds. The interaction of monolayer ices of N2, CO, or CH4 on thin films and porous structures has been analyzed using thermal programmed desorption. The distribution of adsorption sites in the thin films exhibits a single peak, while the porous structure reveals two peaks. The higher-energy peak in the porous structure is attributed to the interaction of volatiles with aromatic structures. Simulations of the desorption of volatiles from dust particles during the heating of cold stellar cores indicate their potential involvement in gas-phase and surface chemistry processes. Additionally, the Specific Surface Area (SSA) of cosmic dust plays a significant role in its chemical reactions, heating, grain growth, and optical properties. The SSA is estimated by monitoring changes in the RAIRS spectra of CO condensed on a cold porous surface as the gas dosage increases. Preliminary results indicate that reducing the size and increasing the porosity of nanoparticles leads to an increase in SSA.

26 - Project SUPERPIG

Gent Frederick

Aalto University School of Science and Technology

In this talk I will present a new computational project on dust formation and processing in the ISM. This projected, SUPERnova-induced Processing of Interstellar Grains (SUPERPIG), is a rather ambitious attempt to push the boundaries of computational astrophysics. We aim to study how supernovae (SNe) interact with the surrounding dusty interstellar medium (ISM) to answer, in particular, two questions: (1) are SNe net producers or net destroyers of dust? (2) Is dust over- or under-abundant in newly formed cold molecular clouds? We seek to answer these questions primarily by means of advanced HPC numerical simulations with the Pencil Code (https://github.com/pencil-code). In addition, we will also study basic material properties of cosmic dust, how grains interact with electromagnetic radiation, and how this is related to ISM dynamics and dust processing. The main novelty of SUPERPIG is an innovative use of zoom-in techniques primarily based MPMD-coupling of the simulation code with itself, which involves time-evolving boundaries and remeshing aided by machine learning. With these new techniques we aim to cover, self-consistently, at least 20 orders of magnitude in simulation length scales, including the large-scale ISM dynamics as well as gas-dust interactions. New observational facilities (e.g. ELT, JWST) will provide a great opportunity to discriminate between various scenarios for cosmic dust evolution, which is why project SUPERPIG represent important and very timely theoretical research.

27 - Radiative transfer through 3D models of dust clouds around AGB-stars

Joachim Wiegert

Uppsala University

During the asymptotic giant branch (AGB) phase, low-to-intermediate mass stars (0.8 - 8 Msol) are characterized by strong mass losses. Important chemical elements (e.g. carbon) produced in their stellar cores are transported by convection to the surface and by intense stellar winds to the interstellar medium. Crucial for these outflows is the formation of dust. Silicate dust (e.g. Mg2SiO4) can form close to the surface of O-rich AGB-stars and is a prime candidate for driving the wind since grains of sizes between 0.1 to 1 micron experience strong radiation pressure due to scattering.

The EXWINGS team develops global radiation-hydrodynamical simulations with CO5BOLD to model the interior of giant stars, outflow of gas, and formation of dust. The first 3D 'star-and-wind-in-a-box' models were recently presented by Freytag & Höfner (2023, A&A 669, A155). I will present work on using these models to simulate images and spectral energy distributions with the 3D radiative transfer program RADMC-3D. These synthetic observables can be used to study the effects of clumpiness, porosity, and other non-spherical morphologies in circumstellar environments. I will also show comparisons with other model setups (e.g. spherical symmetric and point sources) that are common for radiative transfer simulations.

28 - Serendipitous detection of the dusty Type IIL SN 1980K with JWST/MIRI

Szanna Zsíros

Department of Experimental Physics, University of Szeged, Hungary

Core-collapse supernovae (CCSNe) are unique astrophysical laboratories that play an essential role in the cosmic dust cycle and have been long considered one of the primary stellar sources of interstellar dust. However, there are still numerous open questions regarding their contribution. The James Webb Space Telescope (JWST) provides an exceptional opportunity to explore the dust and circumstellar (CSM) interaction in the close environment of CCSNe in details never seen before.

We present mid-infrared (mid-IR) imaging of the Type IIL SN 1980K with the JWST more than 40 yr post-explosion and the analysis of dust formation in its nearby environment. The SN is located in the close so-called 'Fireworks Galaxy' NGC 6946 (D$\sim$7Mpc) and was captured in JWST/MIRI images taken of the field of SN 2004et in the same galaxy. Its fortunate location and evolutionary stage make the SN a promising candidate for studying the transitional phase between young SNe and older SN remnants. We also re-analyzed archive Spitzer data of the SN to investigate the late-time light curve and constrain upper limits on shorter wavelengths.

We fit both analytical and numerical dust models to the spectral energy distributions (SED), as well as model the late-time optical spectrum obtained recently with Keck to draw conclusions on the physical properties of the assumed dust in the environment of the SN. The SED models reveal a surprisingly large amount ($M_d \simeq$ 0.002 solar masses) of silicate-dominated dust at $\sim$150 K (along with a hotter dust/gas component), while the optical line-profile models disclose even larger ($\sim$ 0.16 - 0.60 solar masses) dust masses. Our conclusions suggest two possible scenarios for the SN 1980K observed with the JWST: i) we may see pre-existing CSM-dust heated collisionally similarly to the equatorial ring of SN 1987A, or ii) the mid-IR component of the newly-formed dust with much colder dust located in the ejecta.

29 - Simulating dust dynamics in SPH and MFM hydrodynamical simulations

Giovanni Tedeschi Prades

University Observatory, Faculty of Physics, Ludwig-Maximilians-Universität München

Dust is a fundamental component of the interstellar medium, playing a major role in, for instance, the production of molecular hydrogen and the cooling of gas in galaxies. Although often tightly coupled with the gas, dust may also be an important dynamical element of the interstellar medium, constantly exchanging momentum and energy with the gas, especially when considering larger dust grains in colder and less dense environments. In particular, the study of protoplanetary disk evolution heavily relies on the dynamical study of the dust component, which cannot be simply assumed to be perfectly coupled to the gas phase. Simulating the dynamics of dust in hydrodynamical simulations is a complex computational task, that has often been solved by relying on simplifications. We, instead, implemented the so called One-Fluid model (Laibe, Price 2014) to simulate the dynamics of a mixture of gas and dust self-consistently, automatically including the backreaction of dust onto the gas motion. This theoretical model was applied both to the standard Smoothed Particle Hydrodynamics (SPH) framework as well as to the newly developed Meshless Finite Mass (MFM) one. The latter is an hybrid computational method that aims to use the best out of both the Lagrangian and Eulerian approaches to hydrodynamical simulations. The implementation we developed for the MFM framework can be applied also to standard grid-based codes. We present the theoretical aspects of the One-Fluid model and how it was implemented in this two different hydrodynamical simulation frameworks, as well as the performances of the code in three standard tests for dust dynamics (DUSTYBOX, DUSTYWAVE and DUSTYSHOCK). In addition, we show two possible application tests: the evolution of a Kelvin-Helmholtz instability and a Cold Keplerian Disk in the presence of dust.

30 - Supernova shocks and dust destruction: what role does the environment play?

Nina Sanches Sartorio

Gent University

Supernovae are undoubtedly efficient dust producers during the early stages of their evolution. However, the ensuing forward and reverse shocks are also capable of destroying both the dust in the surrounding interstellar medium and the newly formed dust in the ejecta, respectively. Thus, it is still unclear if supernovae are net dust producers or destroyers. In order to shed light on the importance that the surrounding medium has on the evolution of the supernova explosions, and thus in the net dust content, we ran a number of magneto-hydrodynamical simulations with the code Arepo and post-processed them with dust-processing code Paperboats which includes a myriad of dust destruction mechanisms including sputtering, vaporization and fragmentation. Each simulation has the supernova interacting with turbulent surroundings of varying Mach numbers, average densities and magnetic field strengths. This results in filamentary structures that can be very dense and can protect dust against destruction by the shocks. Furthermore, the shocks themselves evolve in a non-uniform manner which results in a very distinct evolution from that expected to a shock traveling through a uniform medium. In this talk I will show how the evolution of the shocks, and consequently the dust destruction, is sensitive to these parameters and compare these scenarios to the case of the Cassiopeia A supernova remnant.

31 - The effect of dust opacities on winds of carbon-rich AGB stars

Emelie Siderud

Uppsala University

Stars on the asymptotic giant branch (AGB) lose a considerable part of their mass through stellar winds driven by radiation pressure on dust grains. For carbon-rich AGB stars, the main wind-driving species is amorphous carbon, which is a structurally complex material as evidenced by the various laboratory extinction data available. In this study, we use size-dependent dust opacities and compare two optical data sets to investigate how the wind characteristics as well as the grain and photometric properties are affected. Extensive grids of 1D hydrodynamical models, covering a wide range of stellar parameters, are calculated and post-processed to retrieve synthetic observables. The results show that average mass loss rates do not change significantly, however, grain sizes and photometric properties are greatly affected by the different dust opacities.

32 - Paradigmatic examples for testing models of optical light polarization by spheroidal dust

Thomas Vannieuwenhuyse

ESO

We present a general framework on how the polarization of radiation due to scattering, dichroic extinction, and birefringence of aligned spheroidal dust grains can be implemented and tested in 3D Monte Carlo radiative transfer (MCRT) codes. We derive a methodology for solving the radiative transfer equation governing the changes of the Stokes parameters in dust-enshrouded objects. We utilize the Müller matrix, and the extinction, scattering, linear, and circular polarization cross sections of spheroidal grains as well as electrons. An established MCRT code is used and its capabilities are extended to include the Stokes formalism. We compute changes in the polarization state of the light by scattering, dichroic extinction, and birefringence on spheroidal grains. The dependency of the optical depth and the albedo on the polarization is treated. The implementation of scattering by spheroidal grains both for random walk steps as well as for directed scattering (peel-off) are described. The observable polarization of radiation of the objects is determined through an angle binning method for photon packages leaving the model space as well as through an inverse ray-tracing routine for the generation of images. We present paradigmatic examples for which we derive analytical solutions of the optical light polarization by spheroidal dust particles. These tests are suited for benchmark verification of MCpol and other such codes, and allow to quantify the numerical precision reached. We demonstrate that MCpol is in excellent agreement to within 0.1% of the Stokes parameters when compared to the analytical solutions.

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If there is a breach in the Code of Conduct, we would encourage participants to feel safe and secure in reporting this to any member of the LOC for the conference either in person or via their email

- Theo Khouri (theo.khouri@chalmers.se),
- Thiébaut Schirmer (thisch@chalmers.se).
- Martina Šimsová (martina.simsova@gu.se)
- Tom Bakx (tom.bakx@chalmers.se)
- Rasoul Hashemi (seyyedrasoulhashemi@gmail.com)
- Theo Khouri (theo.khouri@chalmers.se)
- David Gobrecht (gobrecht@chalmers.se)
- Matthias Maercker (matthias.maercker@chalmers.se)
- Gustav Olander (gustav.olander@chalmers.se)

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We welcome people to wear masks if they feel that crowding or closeness cannot be avoided to a satisfactory level. We would also suggest participants to engage in self-testing if they develop the symptoms of Covid-19, and to alert the conference organisers if they test positive so that other conference attendees can be made aware. Antigen tests can be found at any pharmacy throughout Gothenburg.