2023 SUMMER SCHOOL PROGRAM

& ABSTRACTS

This program is also available on-line at:
https://ismgalaxies2023.sciencesconf.org/program/details.

CEST Time	Title	Speaker
	Tuesday, July 25th	
	Chair: Eva Ntormousi	
09:15 – 09:25	Welcome & Introduction	Frédéric Galliano
09:25 – 09:30	Overview of the Hands-on Sessions	Karine Demyk
09:30 – 10:30	First Lightning Session	Everyone
10:30 – 11:00	Coffee Break	
	SESSION I **The Modeling Frameworks to Interpret ISM Observations**	
11:00 – 13:00	Photoionization and Photodissociation Models	Benjamin Godard
13:00 – 14:15	Lunch Break	
	Chair: Patrice Theulé	
14:15 – 16:15	Turbulence and Shocks	Pierre Lesaffre
16:15 – 16:30	Coffee Break	
16:30 – 18:00	Hands-on Session	
	Wednesday, July 26th	
	Chair: Eva Ntormousi	
09:30 – 10:30	Second Lightning Session	Everyone
10:30 – 11:00	Coffee Break	
11:00 – 13:00	Dust Models	Nathalie Ysard
13:00 – 14:15	Lunch Break	
	Chair: Karine Demyk	
14:15 – 16:15	Multiline Models of Galaxies: Overview of Modeling Strategies Using Nearby Galaxies as References	Vianney Lebouteiller
16:15 – 16:30	Coffee Break	
16:30 – 18:00	Hands-on Session	
	Thursday, July 27th	
	Chair: Frédéric Galliano & Patrice Theulé	
08:30 – 10:30	First Round Table	B. Godard, V. Lebouteiller, P. Lesaffre & N. Ysard
10:30 – 11:00	Coffee Break	
	SESSION II **Simulations of the ISM at All Scales**	
	Chair: Frédéric Galliano	
11:00 – 13:00	Chemical Evolution of Galaxies: Theories and Observations	Chiaki Kobayashi
13:00 – 14:15	Lunch Break	
	Chair: Vianney Lebouteiller	
14:15 – 16:15	The Galactic Environment and its Connection to the ISM	Rowan Smith
16:15 – 16:30	Coffee Break	
16:30 – 18:00	Hands-on Session	
	Friday, July 28th	
	Chair: Pierre Lesaffre	
08:30 – 10:30	Simulating Star Formation – an Overview from the Basics to the State-of-the-Art	Stefanie Walch
10:30 – 11:00	Coffee Break	
11:00 – 13:00	Interstellar Medium Dynamics and Cosmic Rays Connection to High-Energy Astrophysics	Alexandre Marcowith
13:00 – 14:15	Lunch Break	
	Chair: Eva Ntormousi & Jérôme Pety	
14:15 – 16:15	Second Round Table	C. Kobayashi, A. Marcowith, R. Smith & S. Walch
16:15 – 16:30	Coffee Break	
16:30 – 18:00	Hands-on Session	

CEST Time	Title	Speaker

Monday, July 31th

SESSION III The Observational View of Nearby Interstellar Media		
Chair: Hsiao-Wen CHEN		
08:30 – 10:30	Normal Galaxies: Observational Perspectives	Daniel DALE
10:30 – 11:00	Coffee Break	
11:00 – 13:00	The Cool Galactic ISM: Zooming in on the Physical Processes Driving Star-Formation and Galactic Evolution	Julia ROMAN-DUVAL
13:00 – 14:15	Lunch Break	
Chair: Danny DALE		
14:15 – 16:15	Stellar Feedback and H II Regions: How Stars Affect their Environment	Mélanie CHEVANCE
16:15 – 16:30	Coffee Break	
16:30 – 18:00	Hands-on Session	

Tuesday, August 1st

Chair: Karin SANDSTROM		
08:30 – 10:30	Physical Conditions of the Circumgalactic Medium	Hsiao-Wen CHEN
10:30 – 11:00	Coffee Break	
11:00 – 13:00	ISM and Star Formation in Extreme Environments	Brent GROVES
13:00 – 14:15	Break	
Chair: Chiaki KOBAYASHI		
14:15 – 16:15	The Low Metallicity Interstellar Medium	Karin SANDSTROM
16:15 – 16:30	Coffee Break	
16:30 – 18:00	Hands-on Session	

Wednesday, August 2nd

Chair: Karine DEMYK & Jérôme PETY		
08:30 – 10:30	Third Round Table	H.-W. Chen, M. Chevance, D. Dale, B. Groves, J. Roman-Duval & K. Sandstrom
10:30 – 11:00	Coffee Break	
11:00 – 13:00	Hands-on projects	
13:00 – 14:15	Lunch Break	
Chair: Brent GROVES		
14:15 – 16:05	Hands-on session presentations	
16:05 – 16:15	Concluding Remarks	Frédéric GALLIANO
16:15 – 16:30	Coffee Break	

Photoionization and Photodissociation Models

Benjamin GODARD

(Observatoire de Paris, France)

Tuesday, July 25, 2023, 11:00–13:00

Understanding the reprocessing of radiative energy by interstellar matter is of fundamental importance for theoretical astrophysics and for the interpretation of observations of objects at all scales, from protoplanetary disks to entire galaxies. Over the years sophisticated models of photoionization and photodissociation regions have been developed to capture all the intricacies of the couplings between radiation and matter. In this lecture, I will describe the fundamental microphysical processes that govern the structure, thermodynamical state, and emission of photoinization and photodissociation regions, briefly evoke the current evolution of state-of-the-art models, and present a few application examples.

Turbulence and Shocks

Pierre LESAFFRE

(École Normale Supérieure de Paris, France)

Tuesday, July 25, 2023, 14:15–16:15

In a first part, I will review and succinctly demonstrate some of the known statistical properties of homogeneous incompressible turbulence: the Reynolds number, the Kolmogorov power spectrum and its first intermittency corrections. I will give observational examples relevant to the interstellar medium in our galaxy, and I will point the interested students towards the more advanced textbooks and papers needed to connect turbulence to the complex physics of the interstellar medium. If time allows, I will give a general introduction to intermittency and how it connects to the coherent strong dissipation structures, such as the shocks. This first part will not require any knowledge of hydrodynamics.

In a second part, I will briefly introduce the interstellar matter cycle to show shocks have a role to play everywhere. I will attempt to give estimates on turbulence driving for supernovae shocks, outflows and jets as well as galactic differential rotation. I will briefly introduce fluid dynamics, the concept of linear wave, wave steepening and how shocks are born. I will then examine the Rankine-Hugoniot relations, present the various dissipation processes pertinent to the interstellar medium and show the equations governing the profiles of steady states shock fronts. If time allows, I will discuss various shock types and their stability. Finally, I will present the Paris-Durham shock code and review some of its observational applications in 1D and 3D.

Although no a priori knowledge is required for this lecture, I will try to give hints at where we stand on some the alleys in both these vast subjects. However, I will be far from exhaustive given the short time available. Therefore, and since I am going to be one of the first lecturer, I advise the students to come to me after the lecture if they would like to have more details on some the subjects I will leave aside. I will try to put as much effort as I can to satisfy their curiosity within the boundaries of my own limited knowledge.

Dust Models

Nathalie YSARD

(Institut d'Astrophysique Spatiale, Orsay, France)

Wednesday, July 26, 2023, 11:00–13:00

In this lecture, after a brief overview of the observations used to calibrate the interstellar dust models for our galaxy, we will review the different elements used to define these models. Two public models, one empirical and one based on laboratory measurements, will be described in detail. We will conclude with a few points to bear in mind when analysing data based on dust models.

Multiline Models of Galaxies: Overview of Modeling Strategies Using Nearby Galaxies as References

Vianney LEBOUTEILLER

(CEA Paris-Saclay, France)

Wednesday, July 26, 2023, 14:15–16:15

While the James Webb Space Telescope is providing us with observations of very high-redshift galaxies that redefine our view of galaxy evolution, the corresponding spectra contain a relatively small number of tracers that probe the integrated emission of a galaxy. This leads to some fundamental questions regarding our ability to model and interpret galaxy spectra in order to obtain reliable diagnostics. More generally, it is an incredibly difficult task to extract meaningful quantities from integrated observations of galaxies, which is often the case in multi-wavelength observations. Thankfully, observations of nearby galaxies allow us to distinguish the main emitting components and to observe numerous tracers, which we can use to design the best model strategies possible.

In this presentation, I will first give an overview of the various physical processes at work that produce the tracers we may observe - focusing in particular on the UV-to-IR domain - and describe typical diagnostics that can be drawn from such constraints. Focusing on nearby galaxies, I will then show evidence that many physical components in galaxies contribute to the total emission, implying potential biases due to mixing in integrated spectra or smearing in spatially-resolved observations. The last part will be dedicated to various techniques to account for the complexity of the physical processes and galaxy emitting components, finishing with some avenues to recover actual internal variations in unresolved galaxies.

Chemical Evolution of Galaxies: Theories and Observations

Chiaki KOBAYASHI

(University of Hertfordshire, UK)

Thursday, July 27, 2023, 11:00–13:00

Metallicities, elemental abundances, and isotopic ratios can be measured for stars and the interstellar medium (ISM), and are the key to constraining physical processes during galaxy formation and evolution. During the Big Bang only light elements such as hydrogen and helium were produced. Carbon and heavier elements are created inside stars. Alpha elements are mainly produced from core-collapse supernovae, while the majority of iron-peak elements are from Type Ia supernovae – binary systems. Neutron-capture elements are produced by asymptotic giant branch stars, electron-capture supernovae, magneto-rotational supernovae, collapsars, and/or neutron-star mergers. Integrating the production and recycling of elements, chemical evolution models can predict the time evolution of chemical compositions of stars and the ISM. I will discuss three types of theoretical models: so-called one-zone models, semi-analytic models to include large-scale structure formation of the universe, and the most advanced, chemodynamical simulations. The last model can predict the spatial distribution of elements within a galaxy, often measured as a radial metallicity gradient, as well as the scaling relations of galaxies in the universe. Nowadays, a vast amount of observational data is available for these quantities from galaxy surveys with multi-object spectroscopy (MOS) and integral field unit (IFU). In addition, the Gaia satellite provided detailed kinematics of the Milky Way, the Atacama Large Millimeter Array (ALMA) added chemodynamical information of the ISM, and most recently the James Webb Space Telescope (JWST) is surprising us with the amazing quality of data from nearby to distant galaxies. I will also show some comparison between theoretical predictions and these observational data in this lecture.

The Galactic Environment and its Connection to the ISM

Rowan SMITH

(University of Manchester, UK)

Thursday, July 27, 2023, 14:15–16:15 (remote)

In this lecture we will consider the variety of environments within our galaxy and how they facilitate the creation of star-forming gas. Environments to consider include; the galactic centre, bar, arm, inter-arm and outer galaxy. In all these regimes the turbulence, metallicity, interstellar radiation field, magnetic field, and mean gas density differ, which will affect the formation both of molecular cloud and stars within them. In addition, factors such as galactic shear, differential rotation, and expanding super-bubbles will place additional limits on the evolution and lifetimes of star forming clouds. All these factors mean that star formation in the ISM is intrinsically connected to the galactic environment in which it is embedded.

Simulating Star Formation – an Overview from the Basics to the State-of-the-Art

Stefanie WALCH-GASSNER

(Physical Institute, University of Cologne, Germany)

Friday, July 28, 2023, 08:30–10:30

In this lecture I will give an overview on how to simulate star formation on scales of clumps and cores within molecular clouds and below. I will speak about cloud fragmentation and collapse. We will talk about the cloud (cores') energetics and initial conditions in this context. Further, I will discuss the current ideas on the origin of the stellar initial mass function (IMF) and how it is related with different types of stellar feedback. Stellar feedback also influences the gas in molecular clouds on larger scales. Here, I will speak about the initial phases of the large-scale feedback, particularly the feedback from massive stars, while I will only briefly touch upon the long-term impact of stellar feedback on galactic scales.

Interstellar Medium Dynamics and Cosmic Rays Connection to High-Energy Astrophysics

Alexandre MARCOWITH

(Laboratoire Univers et Particules de Montpellier, France)

Friday, July 28, 2023, 11:00–13:00

This lecture has as main object to present the role of Cosmic Rays (CRs *ie* subnuclear energetic particles) over various aspects of interstellar medium dynamics. The lecture first presents the Cosmic Ray spectrum and its main contributions, a description of multi-wavelength data of Cosmic Ray sources (Supernova remnants, Massive star clusters, Pulsar wind nebulae, young star jets). We then overview some Cosmic Ray Physics: the main acceleration mechanisms and the main processes responsible for the transport of CR in our Galaxy. We will then move to Cosmic Ray Astrophysics by considering the way CRs provide some feed back to star formation at different galactic scales: from large scales through the pressure support driving galactic winds down to small scales via the production of energetic particles (which may at some stage contribute to the CR spectrum). In particular young stars may provide a substantial supply of low energy CRs, ie particles with kinetic energies below their rest mass, which contribute to ionize high column densities of the ISM, ensuring the coupling of matter and magnetic fields.

Normal Galaxies: Observational Perspectives

Daniel DALE

(University of Wyoming, USA)

Monday, July 31, 2023, 08:30–10:30

I will introduce the notion of "normal" galaxies and review their most salient characteristics. Special attention will be given to their morphologies, spectral properties, and star formation histories. Normal galaxies will also be presented in the context of galaxy evolution, including links between what we see locally and what is observed in the distant universe. Finally, I will finish with some thoughts on future areas of study.

The Cool Galactic ISM: Zooming in on the Physical Processes Driving Star-Formation and Galactic Evolution

Julia ROMAN-DUVAL

(Space Telescope Science Institute, Baltimore, USA)

Monday, July 31, 2023, 11:00–13:00

The ISM is a complex, multi-phase turbulent medium that plays a key role in galaxy evolution, with a multitude of physical processes affecting galaxies between stellar and galactic scales. The Galactic ISM provides us with a detailed lens on these physical processes. In this lecture, I will review the physical processes determining the different phases of the ISM. I will focus on the cold neutral phase, which gives rise to molecular clouds and the formation of stars. I will review the state-of-the-art observational knowledge about molecular clouds, their formation mechanisms from atomic clouds, their properties, and location in the Milky Way, and the major questions left open in the field. I will then review the observational and numerical knowledge foundation on the turbulent properties of interstellar gas, and how turbulence in the ISM plays a key role in star-formation. Finally, I will go over recent advancements in our understanding of the star-formation process in the Milky Way, which complements observations of star-formation in other galaxies.

Stellar Feedback and H II Regions: How Stars Affect their Environment

Mélanie CHEVANCE

(University of Heidelberg, Germany)

Monday, July 31, 2023, 14:15–16:15

Stars have a remarkable influence on their surroundings during their lifetime and when they die. They inject energy, momentum, and new elements into their environment, creating a continuous feedback loop. From the small injection scales up to galactic scales, the resulting cascade of mass and energy fluxes generated by stellar feedback constitutes one of the main driver of galaxy evolution. In this lecture, I will describe how stars, especially the massive ones, impact their immediate environment. I will review various mechanisms of stellar feedback that operate on distinct spatial and temporal scales. Additionally, I will demonstrate how cutting-edge, high-resolution, multi-wavelength observations of young star-forming regions in nearby galaxies, coupled with state-of-the-art numerical simulations, provide valuable insights into the nature and characterisation of these processes.

Physical Conditions of the Circumgalactic Medium

Hsiao-Wen CHEN

(University of Chicago)

Tuesday, August 1, 2023, 08:30-10:30

This lecture will provide a broad overview of key objectives in the circumgalactic medium research and how they are connected to the overall understanding of galaxy formation and evolution. We will review different empirical constraints that can be inferred from absorption and emission observations with particular attention on systematics.

ISM and Star Formation in Extreme Environments

Brent GROVES

(University of Western Australia)

Tuesday, August 1, 2023, 11:00–13:00

In this lecture I will go beyond the 'normal' galaxies of the last lecture to look at the ISM in more extreme environments such as ULIRGs, Starbursts, AGN and highly turbulent regimes. I'll describe how we find and calssify such objects and extend the ISM discussion onto how stars form from the ISM, as it is here that we see the big differences between normal galaxies and these extreme environments.

The Low Metallicity Interstellar Medium

Karin SANDSTROM

(University of California, San Diego, USA)

Tuesday, August 1, 2023, 14:15–16:15

Metallicity is one of the key parameters that governs the physics of the interstellar medium (ISM). Through its effects on a wide range of heating and cooling processes, metallicity is critical to setting the phase balance of the ISM. Because it also governs the dust-to-gas ratio, metallicity affects all ISM processes that depend on dust. In this lecture, I will describe our understanding of how low metallicity impacts the physical processes in the ISM. I will outline what observational constraints exist for the low metallicity ISM and the prospects for future observations, simulations, and theory in this area.