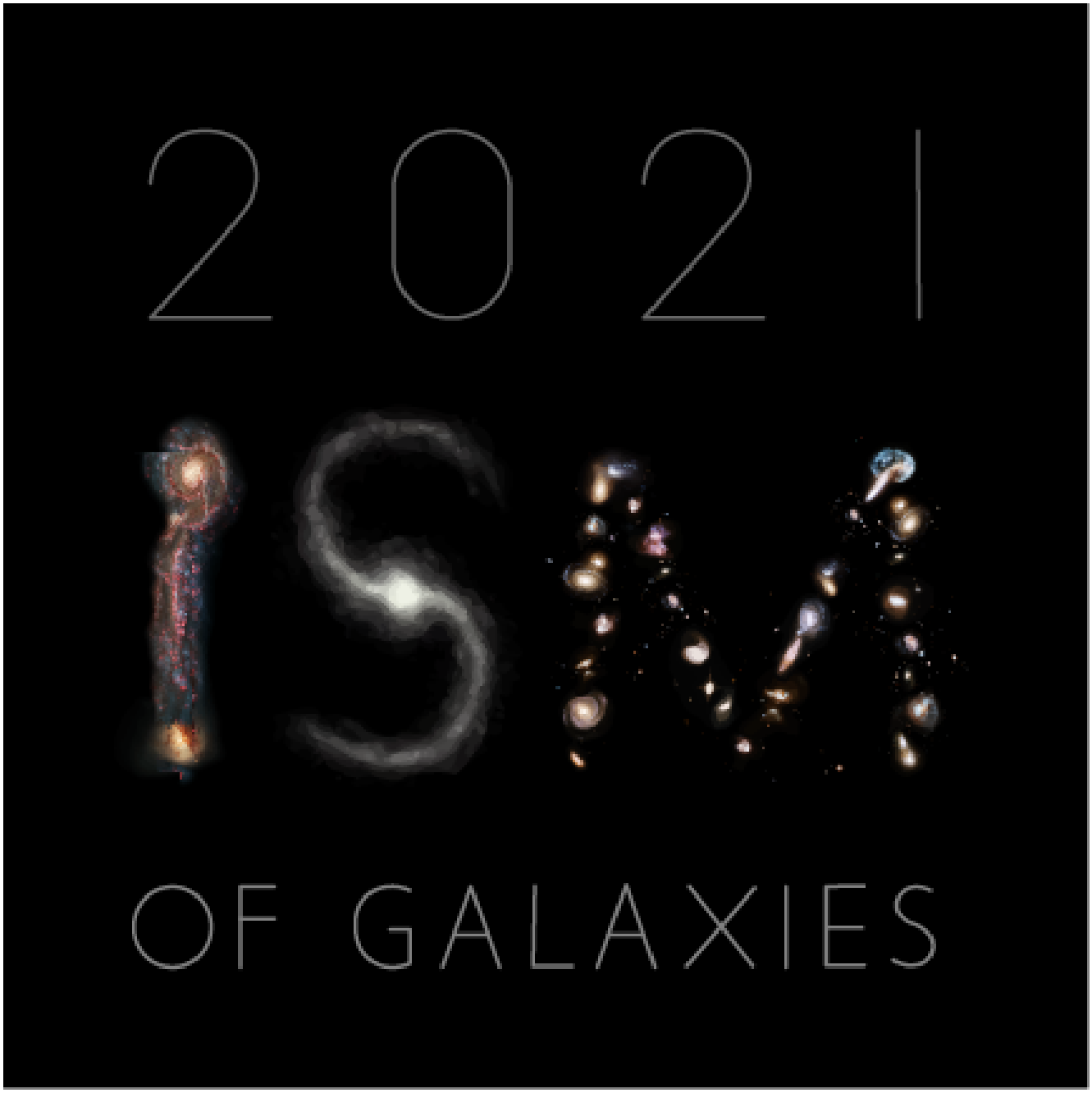

SUMMER SCHOOL PROGRAM

& ABSTRACTS

This program is also available on-line at:
https://ismgalaxies2021.sciencesconf.org/program.

WEEK I

CEST Time	Title	Speaker
	Monday, July 12th	
13:15 – 13:30	Welcome & Introduction	The SOC
	SESSION I **Inventory of the ISM Properties Across Galaxies**	
	Chair: Guilaine Lagache	
13:30 – 15:15	An Observational Inventory of the ISM Properties of Nearby Galaxies	Adam Leroy
15:15 – 15:45	Break	
15:45 – 17:30	Observational Inventory of the ISM Properties of Galaxies at the Cosmic Noon	David Elbaz
17:30 – 18:00	Break	
18:00 – 19:00	Hands-on projects	
	Tuesday, July 13th	
	Chair: Jérôme Pety	
13:30 – 15:15	The ISM of the First Galaxies: a Theoretical Perspective	Andrea Ferrara
15:15 – 15:45	Break	
15:45 – 17:30	Molecular Clouds and Star Formation in the Milky Way	Frédérique Motte
17:30 – 18:00	Break	
18:00 – 19:00	Hands-on projects	
	Wednesday, July 14th	
	Chair: Annie Hughes	
13:30 – 15:15	Galactic Observations of the Multiphase Magnetized ISM	François Boulanger
15:15 – 15:45	Break	
15:45 – 17:30	Hands-on projects	
	Thursday, July 15th	
	SESSION II **Models to Interpret ISM Observations**	
	Chair: Frédéric Galliano	
13:30 – 15:15	Physics and Spectrum of Interstellar Matter	Gary Ferland
15:15 – 15:45	Break	
	Chairs: Guilaine Lagache & Frédéric Galliano	
15:45 – 17:30	Round table about the inventory of the ISM properties across galaxies	Boulanger, Elbaz, Ferrara, Leroy & Motte
17:30 – 18:00	Break	
18:00 – 19:00	Hands-on projects	
	Friday, July 16th	
	Chair: Patrice Theulé	
13:30 – 15:15	Photodissociation Region Models (PDR Models)	Émeric Bron
15:15 – 15:45	Break	
15:45 – 17:30	Interstellar Shock Models	Sylvie Cabrit

WEEK II

CEST Time	Title	Speaker
	Monday, July 19th	
	Chair: Nicolas Bouché	
13:30 – 15:15	Interstellar Dust Properties and Cosmic Dust Models	Karine Demyk
15:15 – 15:45	Break	
15:45 – 17:30	Dust and Stars Interplay in Galaxies	Véronique Buat
17:30 – 18:00	Break	
18:00 – 19:00	Hands-on projects	
	Tuesday, July 20th	
	SESSION III **The Perspective from Numerical Simulations**	
	Chair: Nathalie Ysard	
13:30 – 15:15	Star Formation in the Milky Way: from Clouds to Protostars	Benoît Commerçon
15:15 – 15:45	Break	
	Chairs: Nathalie Ysard & Jérôme Pety	
15:45 – 17:30	Round table about the models to interpret ISM observations	Bron, Buat, Cabrit, Demyk & Ferland
17:30 – 18:00	Break	
18:00 – 19:00	Hands-on projects	
	Wednesday, July 21th	
	Chair: Patrice Theulé	
13:30 – 15:15	Large Scale Galactic Dynamics: the Perspective from Numerical Simulations	Florent Renaud
15:15 – 15:45	Break	
15:45 – 17:30	Hands-on projects	
	Thursday, July 22th	
	Chair: Annie Hughes	
13:30 – 15:15	Stellar Feedback and Its Effects on the ISM and Star Formation Regulation	Eve Ostriker
15:15 – 15:45	Break	
	Chair: Annie Hughes & Patrice Theulé	
15:45 – 17:30	Round table about the perspective from numerical simulations	Commerçon, Ostriker, Renaud & Schneider
17:30 – 18:00	Break	
18:00 – 19:00	Hands-on projects	
	Friday, July 23th	
	Chair: Frédéric Galliano	
13:30 – 15:15	Modeling Metal and Dust Enrichment in the First Galaxies	Raffaella Schneider
15:15 – 15:45	Break	
15:45 – 17:30	Hands-on project presentations (8 minutes per project)	Hands-on students
17:30 – 17:40	Concluding remarks	The SOC

An Observational Inventory of the ISM Properties of Nearby Galaxies

Adam LEROY

(Ohio State University, USA)

Monday, July 12, 2021, 13:30–15:15 (CEST)

This lecture will give an observational overview of the contents of the interstellar medium (ISM) in present day (z=0) galaxies. I will review the basic contents of the ISM in different types of galaxies, including discussing the atomic gas, molecular gas, and dust in late-type, early-type, and dwarf galaxies. I will also touch on some of the key observational techniques to measure these properties and I will summarize some of the basic structural properties of the ISM within galaxies.

Observational Inventory of the ISM Properties of Galaxies at the Cosmic Noon

David ELBAZ

(Département d'Astrophysique, CEA/Saclay, France)

Monday, July 12, 2021, 15:45–17:30 (CEST)

This lecture will give an observational account of what we know about the evolution of galaxies (main sequence *vs.* starbursts) and other evolutionary factors (mergers, AGN, *etc.*) at the epoch of the peak of star formation ($z \simeq 1-2$).

The ISM of the First Galaxies: a Theoretical Perspective

Andrea FERRARA

(Scuola Normale Superiore, Pisa, Italy)

Tuesday, July 13, 2021, 13:30–15:15 (CEST)

Understanding the ISM of the first galaxies is a key step to build a coherent galaxy formation and evolution scenario, and to interpret their observed properties. This is crucial in an era in which ALMA and JWST are/will provide exquisite data of the faintest objects at high spectral and spatial resolution. The physical conditions prevailing in the first cosmic Gyr were dramatically different with respect to present-day ones. This profoundly affects the internal structure and dynamics of early galaxies and of their interstellar component. The Lecture will start from a general review of the properties of high-z galaxies descending from the concordance cosmological model, to then assess their implications for the ISM thermodynamics, energetics and composition. These basic physical descriptions will be confronted with available phenomenology to identify critical areas, and define a set of pillars that are fundamental to understand and produce the most advanced research in the field.

Useful references related to the lecture:

- Spitzer, Physical Processes in the Interstellar Medium (book)
- Osterbrok, Astrophysics of Gaseous Nebulae and AGN (Book)
- Ostriker & McKee, 1988, Rev. Mod. Phys. 60, 1
- Dayal & Ferrara, 2018, Phys. Rep., 780, 1

Molecular Clouds and Star Formation in the Milky Way

Frédérique MOTTE

(IPAG, Grenoble, France)

Tuesday, July 13, 2021, 15:45–17:30 (CEST)

In this lecture, I will first describe where clouds and star-forming regions are located in our Galaxy. I will then present the basic properties of molecular clouds and various statistical tools developed to characterize them. I will also discuss the current theories on cloud formation and how clouds properties can impact the process of star formation.

Galactic Observations of the Multiphase Magnetized ISM

François BOULANGER

(École Normale Supérieure, Paris, France)

Wednesday, July 14, 2021, 13:30–15:15 (CEST)

The physics of diffuse matter in galaxies is a cornerstone of galaxy evolution. The ISM plays a dual role because it is both a heat reservoir and a cooling agent. On the one hand, the turbulent multiphase structure of the ISM is driven by feedback processes and, on the other hand, the ability of this medium to cool controls the formation of gravitationally bound molecular clouds where stars form. This lecture will provide insights into the multi-wavelength Galactic observations that contribute to our understanding of ISM physics. While telescopes offer ever greater sensitivity and angular resolution to study the ISM in external galaxies, Galactic observations remain best suited to study some key aspects, notably the multiphase structure of interstellar matter, the turbulent energy cascade across scales and phases, and the interplay between gas dynamics and interstellar micro physics. I will illustrate these topics by showing how observations inform us about the structure and energetics of the ISM, interstellar magnetic fields and the life cycle of dust.

Physics and Spectrum of Interstellar Matter

Gary FERLAND

(University of Kentucky, USA)

Thursday, July 15, 2021, 13:30–15:15 (CEST)

The spectrum is how we understand what is happening in the interstellar medium, and the telescope is how we measure the spectrum. I will talk about how the spectrum is formed and how we can use simulations to understand what the spectrum tells us about what is happening in front of our telescopes.

Photodissociation Region Models (PDR Models)

Émeric BRON

(LERMA, Observatoire de Meudon, France)

Friday, July 16, 2021, 13:30–15:15 (CEST)

Photodissociation regions (PDRs) are regions of neutral ISM whose physics and chemistry are driven by the impact of stellar FUV photons. Located in particular at the surface of molecular clouds in star forming regions, they reprocess a significant fraction of the light of the newborn stars into infrared emission (dust and line emission), contributing a major fraction to the total infrared spectrum of galaxies, and providing us with a wealth of tracers to study the physical conditions and feedback processes in star forming regions. In this lecture, I will introduce the numerous physical and chemical processes that govern PDRs and their emission. I will start from the most fundamental (H_2 formation and photodissociation) and progressively add details towards a more complete picture of PDRs. For each physical and chemical process, I will discuss existing modeling approaches. An overview of the observable tracers in different wavelength domains and of their link to the physical conditions will also be presented.

Interstellar Shock Models

Sylvie CABRIT

(LERMA, Observatoire de Paris, France)

Friday, July 16, 2021, 15:45–17:30 (CEST)

Shocks are ubiquitous in the interstellar medium, driven by cloud collisions, stellar jets and winds, and supernova remnants. I will present an introduction to the basic physics of shock waves and describe the various types of shock structure that can develop in the ISM, depending on shock speed and the ambient level of magnetization and irradiation: jump (J-type) shocks dominated by viscous friction, continuous (C-type) shocks dominated by ion-neutral drift, intermediate C* and C-J shocks, dissociative and ionizing shocks. I will discuss the typical predicted diagnostics, in particular with the Paris-Durham code for dusty molecular shocks.

Interstellar Dust Properties and Cosmic Dust Models

Karine DEMYK

(Institut de Recherche en Astrophysique et Planétologie, Toulouse, France)

Monday, July 19, 2021, 13:30–15:15 (CEST)

This lecture will review the current dust models and the techniques aimed at deriving relevant physical parameters from observations. It will focus on the optical properties of interstellar grains, as well as dust emission and extinction. It will discuss in situgrain evolution as a function of the UV field and density. This lecture will not only discuss the underlying physics, but also the available diagnostics, as a function of environmental conditions, spatial resolution and spectral coverage.

Dust and Stars Interplay in Galaxies

Véronique BUAT

(Laboratoire d'Astrophysique de Marseille, France)

Monday, July 19, 2021, 15:45–17:30 (CEST)

In this lecture I will present the context of studies of dust obscuration in galaxies, mots of the time unresolved. I will present the main concept, in particular from radiative transfer modelling, the derivation of effective attenuation laws and discuss popular empirical relations to measure the amount of attenuation. I will briefly conclude on the impact of this interplay on key galactic parameters as star formation rates and stellar masses.

Useful references related to the lecture:

- Salim & Narayanan, 2020, ARAA, 58, 129
- Calzetti, 2012, Proceedings of the XXIII Canary Islands Winter School of Astrophysics: 'Secular Evolution of Galaxies', astro-ph/1208.2997
- Chevallard et al. 2013, MNRAS 432, 2061
- Narayanan et al. 2018, ApJ 869, 70

Star Formation in the Milky Way: from Clouds to Protostars

Benoît COMMERÇON

(Centre de Recherche Astrophysique de Lyon/ENS Lyon, France)

Tuesday, July 20, 2021, 13:30–15:15 (CEST)

Star forms in giant molecular clouds which exhibit turbulent motions and magnetic fields. Understanding how fast and how efficiently these molecular clouds convert diffuse gas into stars is key to better constrain the impact of star formation on galactic evolution. Second, we need to understand the origin of the stellar initial mass function (IMF) in order to calibrate star formation sub-grid models at galactic scales. When stars form, they inject energy and momentum in their surrounding via various stellar feedback processes: jets and outflows, stellar winds, radiation and eventually supernovae explosion. Together with magnetic fields and turbulence, all these feedback processes are expected to play an important role in the establishment of the stellar IMF. Last, at the scales of individual protostars, protostellar disks, the precursors of protoplanetary disks, are forming and trigger planet formation, which potentially connects planet formation to galactic evolution through star formation.

I will review our current understanding of star formation within molecular clouds, starting from the large scales (molecular clouds formation) down to the protostellar scales (cloud collapse). I will illustrate how fundamental problems of star formation (star formation rate and efficiency, IMF) can be better understood thanks to numerical experiments. I will finally conclude by recalling what are the main challenges left to future numerical experiment developments.

Large Scale Galactic Dynamics: the Perspective from Numerical Simulations

Florent RENAUD

(Lund Observatory, Sweden)

Wednesday, July 21, 2021, 13:30–15:15 (CEST)

Observations resolving the internal structures of nearby disk galaxies reveal the key role of large-scale dynamics in setting the organization of the ISM and influencing star formation. At the same time, feedback from young stars couples to galactic scales in a non-trivial way, such that the interplay between large and small scales is still not fully understood. The tight connection between galaxies, clouds and stars is being explored by numerical simulations of disk galaxies, with or without cosmological context, but the enormous range of scales and physical processes involved remains challenging. In this lecture, I will briefly introduce the different type of simulations. I will explain how galactic dynamics and galactic structures like spiral arms and bars influence the evolution of the ISM and the formation of stars. I will summarize the state-of-the-art of simulation efforts and will present the results obtained to illustrate and quantify this multi-physics and multi-scale coupling. I will conclude by listing a few open questions and challenges for the future and the next generations of simulations.

Stellar Feedback and Its Effects on the ISM and Star Formation Regulation

Eve OSTRIKER

(Princeton University, USA)

Thursday, July 22, 2021, 13:30–15:15 (CEST)

On both scales of individual star-forming clouds, and scales of the whole ISM, stellar feedback — primarily associated with high-mass stars — has profound effects on the state of the ISM. Feedback therefore controls the ability of gas to collapse and form further stars, so that star formation rates and efficiencies can be self-regulated. In this lecture, I will begin by reviewing the main feedback agents, and the mechanisms by which they interact with their surroundings. These feedback agents include photo ionizing (EUV) radiation, non-ionizing (FUV) radiation, dust-reprocessed radiation, stellar winds, and supernovae. Radiation and shocks can directly heat and ionize gas, and the pressure forces from radiation and ionized gas also dynamically affect neutral gas. I will present numerical simulations of both star-forming GMCs and the large-scale ISM evolving under the effects of radiation, wind, and supernova feedback. While it has long been appreciated that feedback is crucial, simulations make it possible to evaluate the relative importance of different feedback mechanisms, and to quantitatively test the self-regulation paradigm. While there remain many opportunities for further research, current theoretical and computational results show promising agreement with observations.

Modeling Metal and Dust Enrichment in the First Galaxies

Raffaella SCHNEIDER

(Sapienza, Università di Roma, Italy)

Friday, July 23, 2021, 13:30–15:15 (CEST)

The birth of the first stars in the Universe is accompanied by the first production of elements heavier than helium. The release of the newly produced metals in the surrounding medium has a dramatic impact on gas cooling and the nature of subsequent stellar populations. The physical conditions present in supernova ejecta and in the winds of intermediate mass stars on the asymptotic giant branch enable the condensation of the first solid grains. These, in turn, affect the efficiency of star formation by favoring molecular hydrogen formation and play an important role in the thermal properties of the interstellar medium. Finally, the presence of dust change the appearance of distant galaxies, by absorbing UV radiation and re-emitting it in the far IR. In this lecture, I will try to give an overview on some of these important elements that are essential to interpret observations of distant galaxies and to help us understand how the Universe emerged from the cosmic dark ages.