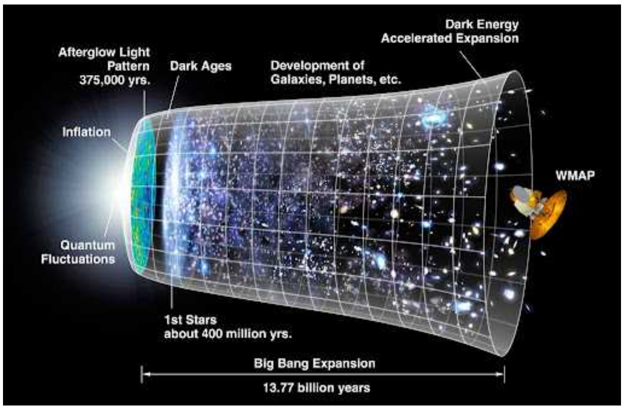
UE Stars & galaxies



I. The physics of galaxies

Lecture 1: Introduction: The world of galaxies (1.5h)

- MW as a galaxy. Orders of magnitude. Classification. Global properties in the Local Universe
- Census of components in the MW and other galaxies. Stellar populations. BH and AGN.
- The Spectral Energy Distribution of galaxies (basic ideas)
- Dark Mater at galaxy scales.
- Large Scale Structure (basics): from the local universe to LSS. Clusters of galaxies.
- Large surveys and galaxy formation history (basics)

Lecture 2: Evolution of galaxies: Basic equations, analytic and numerical models, chemical evolution (2.5h)

- Basic Concepts
- Equations, hypothesis and the basics of galaxy (chemical) evolution
- Determination of the IMF
- Analytic approximations for the evolution of galaxies (chemical aspects)
- Building numerical models
- Chemical evolution in the Solar neighborhood
- Chemical evolution of galaxies
- Analytic approximation to the (spectro)photometric evolution of galaxies (and limitations!)

II. Galaxy spectral energy distribution

Lecture 3: How to interpret the observed light received from galaxies ? (3h)

- Light from stars (single and composite stellar population)
- Emission and absorption lines (links to parameters)
- Dust (loi d'atténuation, Dale, Calzetti, macrospocic views, links with observations
- Deriving statistical functions

Lecture 4 : Inventory of the interstellar medium (2h)

- the different phases of the interstellar medium
- simple models of the interstellar medium

Lecture 5 : Physics of the interstellar medium (4h)

- the energy budget, heating and cooling

- nebular emission lines and absorption lines
- dust absorption, scattering and emission

III. Feedback mechanisms

Lecture 6 : Feedbacks at small scales (2h)
- interstellar medium evolution with super novae and stellar feedback

Lecture 7: Feedback at large scale(2h)
- Stellar feedback (winds and outflows from supernova)
- AGN feedback (from the accretion disk around supermassive black holes)

IV. Galaxy evolution

Lecture 8: Disk galaxies and their secular evolution (3h)
- Formation of a stellar disk
- Galaxy Kinematic: observations
- Galaxy Kinematic: some applications
- Dynamical evolution

Lecture 9: Elliptical galaxies and quenching: a violent history (2h)
- Galaxy properties (morphology, kinematic, scaling relations, supermassive black hole)
- Formation scenario and mergers

V. High-redshift galaxies

Lecture 10: Formation of the first galaxies and Reionization (2h)
- Present constrains on the Re-ionization epoch & galaxy formation scenarios. Sources of the reionization.
- Theoretical considerations: Hierarchical formation and abundance of CDM halos. Mass profiles. Press-Schechter formalism. Characteristic properties of collapsing halos. Galaxy formation models. Halo mass function. First stars and first galaxies. Reionization process.
- Observational approaches : Identification and characterization of primeval galaxies. Observational signatures & properties. Observational Techniques.
- Present results … and open issues. Discussion. Perspectives

Lecture 11 : the interstellar medium of the first galaxies (2h)
- evolution of the interstellar medium after reionization
- physics of the interstellar medium before reionization

Lecture 12: Galaxy Assembly and Evolution in DM structures, clustering (2h)
- The Large Scale Structure (LSS) traced by galaxies. Large samples of galaxies from cosmological surveys.
- Cosmological simulations of Galaxy Formation
- Large Scale Structure and clustering properties: Mapping the density field. 2P correlation function (3D & projected CF). Redshift-space distortions. Galaxy bias. 2PCF in the local universe. 2PCD in the distant universe & redshift evolution. Connecting Galaxies to DM halos (Halo model interpretation, HOD + results)

Projects :

to choose one project among

project 1 : a travel in space and time

The main objective of this project is to simulate the time evolution of the stars in a globular cluster. We will monitor this evolution on the theoretical Hertzprung-Russel diagram (HRD) and on a color-magnitude diagram (CMD) to simulate what an observer would see from various positions in time and space. The Python programming language will be used and more specifically Matplotlib animations.

project 2: new insights on the first galaxies from the *James Webb Space Telescope*

The primary objective of this project is to determine how the luminosity distribution of galaxies evolved within the first billion years of the Universe and showcase the impact of JWST on our understanding of the early Universe. You will develop several Python scripts in a *Jupyter Notebook* to read the JWST catalog, select galaxies within the first billion years, and extract the required information.

References

- Mo and White: Galaxy formation and evolution
- Binney: galactic astronomy and galactic dynamics
- Draine: physics of the intersettalr medium and intergalactic medium

Prerequisite

- M1 planets & stars