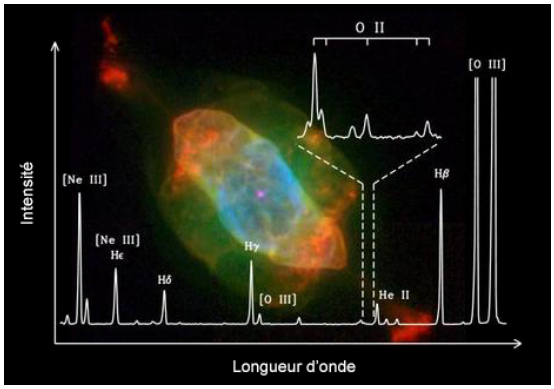
Astrophysics of Gaseous and Dusty Nebulae



SUMMARY.
Gaesous nebulae and dusty environments play an important role in astrophysics. H II regions and Planetary Nebulae, ionized by hot stars, can provide informations related to stellar formation and evolution, in connection to the chemical evolution of galaxies. In addition, dust formation can hamper the derivation of physical properties of such objects.

Keywords: Stellar physics and evolution - Diffuse medium - HII/HI regions - Dust and gas in circumstellar envelopes

OBJECTIVES

- This METEOR aims at making the students familiar with the physical study of gaseous and dusty environments from theoretical and high-resolution observational points of view.
- The theory of ionization and thermal equilibria associated to radiative transfer in nebulae will be presented. Practical projects based on high-resolution images of circumstellar environments and collected with ESO/VLT instruments will also be proposed.

PREREQUISITES

- ✗ S1. General astrophysics
- ✗ S2. Stellar physics

THEORY

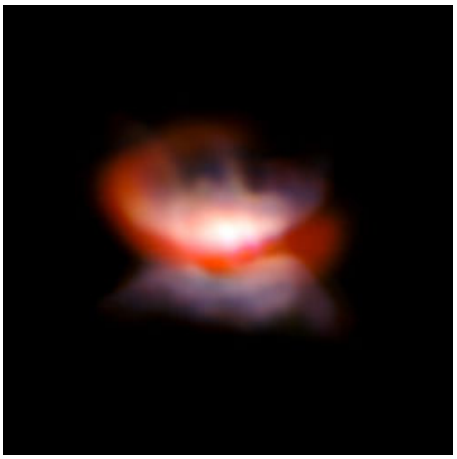
by Patrick de Laverny

All stars are formed from interstellar material and synthetize new chemical elements during their life. These newly formed elements can then be injected back to the interstellar medium during the ultimate phases of stellar evolution. Understanding star formation and the final stages of their evolution is thus a key to understand the chemical evolution of the Universe. During their ejection phases, stars can be surrounded by circumstellar material (ionized or neutral gas and dust). As all the informations we can obtain from these objects come from their emerging light, we need to study how photons interact with gas and dust.

This first part will allow to understand the different types of gaseous nebulae, to study the physics of gas ionisation by hot photons, to understand the formation of emission spectra for these objects and how we can determine physical properties and chemical abundances.

by Eric Lagadec

Dust particles play also an important role in circumstellar envelopes of evolved stars. The students will also become familiar with dust radiative transfer, to study the interaction of light with circumstellar dust particles.



The dusty circumstellar envelope of L2 Pup.

APPLICATIONS

by Eric Lagadec

The students will then get their hands on state of the art data and modeling codes. They will be taught how to analyse data taken with the Very Large Telescope (VLT) in Chile with instruments like VISIR and SPHERE. They will learn how to derive the morphological, physical and chemical properties of circumstellar environments. This will be done by using the dust radiative transfer code DUSTY and optical and infrared diffraction limited images using extreme adaptive optics. They will thus learn how to measure physical parameters of the circumstellar environment via modeling of the observations, thus directly applying the theoretical knowledge they acquired before.

MAIN PROGRESSION STEPS

- `Tiers 1 & 2`: courses A & B and exercices
- `Tier 3`: personnal project

EVALUATION

- `Theory grade [30%]`
  - Written exam (70%): theoretical questions from lectures
  - Presentation of an article (30%): critical spirit and answer to questions
- `Practice grade [30%]`
  - Exercices (30%): thought-process and results
  - Project (70%): initiative, progress, analysis
- `Defense grade [40%]`
  - Oral and slides quality
  - Context
  - Project / Personal work
  - Answers to questions

BIBLIOGRAPHY & RESOURCES

- *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei*, D.E. Osterbrock & G.J. Ferland

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