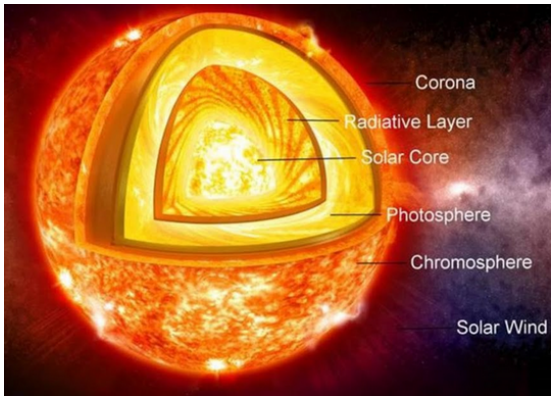
Stellar Physics



— OBJECTIVES

The first part of these series of lectures is dedicated to understanding the structure of stars and how physical and thermodynamical processes intervene. By coupling these lectures with knowledge of nucleosynthesis, the concepts of stellar evolution will be presented, along with an analysis on the impact of mass and chemical composition on evolution and therefore the observable properties of stars.
The second part of these series of lectures is dedicated to the physical processes taking place in a stellar atmosphere, the transition region between the interior of a star and the interstellar medium from which photons escape. The study of stellar atmospheres is a huge endeavour, almost all physics is involved: radiative transfer, atomic physics, statistical physics, hydrodynamics, etc ... We will adopt an in-depth approach, covering as many physical details as we can, giving the student the necessary background to be able to get into the literature on this topics.

— EVALUATION

- Homework and project (50%)
- End-of-term written exam (50%)

— MAIN PROGRESSION STEPS

- `First half`: Courses and exercises on stellar interiors & Evolution
- `Second half`: Courses and exercises on stellar atmospheres

— BIBLIOGRAPHY & RESOURCES

- An introduction to Stellar Astrophysics, Volume 3, stellar structure and evolution, E. Böhm-Vitense, 2008
- Stellar Astrophysics, (LeBlanc)
- Lecture notes in Stellar Structure and Evolution (Christensen-Dalsgaard)
- Stellar Atmospheres, D. Mihalas, 1970
- Theory of Stellar Atmospheres, I. Hubeny & D. Mihalas, 2015
- The Observations and Analysis of Stellar photospheres, D.F., Gray, 2022
- An Introduction to Modern Astrophysics, B.W. Carroll, D.A. Ostile, 2007
- Radiative Transfer in Stellar Atmospheres, R.J. Rutten, 2003

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Content

— Part. 1 - Stellar Interiors and Evolution

by O. Creevey

- Introduction
- Stellar Structure
  - Hydrostatic equilibrium
  - Mass conservation
  - Virial Theorem
  - Polytropic models
  - Energy transfer equations
  - Conservation of energy
  - Criteria for convection

- Nucleosynthesis
  - Binding energy
  - Timescales
  - Conditions for nuclear fusion
  - Nuclear reactions
  - Energy generation
- Stellar Evolution
  - Stellar formation
  - Main sequence evolution
  - Impact of mass, mean molecular weight, chemical composition
  - Post main sequence evolution

— Part. 2 - Stellar Atmospheres

by G. Niccolini

- Introduction
- Radiative transfer
  - Specific intensity
  - Moments of the radiation field
  - Plan-parallel geometry
  - Radiative transfer equation
  - Formal solution
  - Radiative equilibrium
- Simple atmosphere models
  - Simplifying assumptions
  - Eddington approximation
  - Eddington + one lambda-iteration
  - Gray atmosphere in radiative equilibrium
- Equation of state
  - Review of statistical physics
  - Law of mass action and Saha equation
  - Ionization equilibrium
- Opacities
  - Continuum
  - Atomic physics in a nutshell
  - Lines
  - Continuum absorption cross-sections
- Stellar atmosphere models
  - LTE model atmosphere for the continuum
  - Line radiative transfer
  - Pure H atmosphere in LTE