ASTR3C34: THE PHYSICS AND EVOLUTION OF STARS

Aims:

1. To provide a quantitative introduction to our knowledge of the physical structure of stars.
2. To provide the basic theory of radiative and convective energy transfer in stellar atmospheres and interiors.
3. To provide a basic description of how stars evolve.
4. To provide a firm preparation for the 4th year course ASTR4C16 - Advanced topics in stellar atmospheres and evolution.

Objectives:

On successful completion of this course, a student should be able to:

- define the basic quantities describing a radiation field (specific intensity, mean intensity and energy density, flux and radiation pressure moment).
- understand the basic concepts of opacity, emissivity, the source function and optical depth, and the assumption of Local Thermodynamic Equilibrium (LTE).
- derive the basic equations governing the physical structure of a star (hydrostatic equilibrium, continuity of mass and energy, radiative energy transport).
- derive the equation of radiative transfer for a stellar atmosphere in the case of the plane-parallel approximation, and its formal solution for the specific intensity, mean intensity and flux.
- derive the equations of radiative equilibrium.
- understand the basics of the construction of LTE model atmospheres.
- describe the basic physical atomic processes that contribute to the opacity of gas in stellar atmospheres and interiors; the frequency-dependence of each source of opacity and their relative importance in stars of different effective temperature.
- derive the expression for the Rosseland mean opacity and understand approximate forms of opacity (i.e. Kramers' opacity law).
- describe the process of energy transport by convection in stellar interiors and atmospheres.
- derive the Schwarzschild Criterion for convective instability, and the formulation for the convective flux in the simple Mixing Length theory of convection.
- discuss the concept of a polytropic change and derive the Lane-Emden equation.

- discuss the application of the Lane-Emden equation to stars and derive the mass-radius relation for a polytrope, the Chandrasekhar mass and the Eddington Standard Model.
- discuss the characteristic timescales of stellar evolution.
- discuss the evolution of proto-stars onto the main sequence and the concept of Hayashi tracks.
- describe the theoretical aspects of the main sequence and the concept of homology relations.
- describe evolution on the main sequence and the concept of upper and lower main sequence stars.
- describe evolution off the main sequence to the red giant branch.
- understand the dependence of mass on post main sequence evolution.
- give a detailed description of the evolution of intermediate mass stars beyond the red giant branch.
- give a detailed description of the evolution of high mass stars and understand the general effects of mass loss on the evolution of stars.