

Structure and Evolution of Stars (M24)

Professor C. A. Tout

The structure of a star can be mathematically described by certain differential equations which can be derived from the principles of hydrodynamics, electromagnetic theory, thermodynamics, quantum mechanics, atomic and nuclear physics. Some familiarity with these theories will be assumed.

The basic equations of a spherical star will be derived in detail and the mode of energy transport, the equation of state, and the physics of the opacity sources and the nuclear reactions will be discussed.

Approximate solutions of the equations for stellar structure will be given. Attention will be given to the virial theorem, polytropic gas spheres and homology principles. The procedure for numerical solution of the equations will be mentioned briefly.

The evolution of a star will be discussed with reference to its main-sequence evolution, the exhaustion of various nuclear fuels and the end points of evolution such as white dwarfs, neutron stars and black holes.

Close binary stars are two stars in a gravitationally bound system in which the ratio of orbital separation to stellar radius is sufficiently small for the stars to interact through tides and mass transfer. The concept of Roche lobe overflow and its stability will be discussed, as well as the effects on the stellar evolution. Algols and Cataclysmic Variables will be considered as observed examples.

Throughout the course, reference will be made to the observational properties of stars and these will be discussed at appropriate times with particular reference to the Hertzsprung-Russell diagram, the mass-luminosity law and spectroscopic information.

There will be four examples sheets each of which will be discussed during an examples.

Prerequisites

A basic understanding of the principles of hydrodynamics, electromagnetic theory, thermodynamics, quantum mechanics, atomic and nuclear physics.

Preliminary Reading

1. Shu, F. *The Physical Universe*, W. H. Freeman University Science Books, 1991.
2. Phillips, A. *The Physics of Stars*, Wiley, 1999.

Literature

1. J. J. Eldridge and C. A. Tout, *The Structure and Evolution of Stars* World Scientific, 2019.
2. Prialnik, D. *An Introduction to the Theory of Stellar Structure and Stellar Evolution*, CUP, 2000.
3. J. E. Pringle and R. A. Wade *Interacting Binary Stars*, CUP, 1985.

Additional support

There will be four examples sheets each of which will be discussed during an examples class.
There will be a revision class in the Easter term.