Structure and Evolution of Stars (M24)

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The only way we know how to form heavy elements is through stellar processes. Thus stars are central in building the world around us. This course will be an elementary introduction to our attempts at gaining insight into the structure and evolution of stars relying on a mathematical description of the physical processes which determine the nature of stars. Such a description naturally follows the laws of conservation of mass, momentum and energy. The basic equations for spherical stars and necessary boundary conditions will be discussed. These equations have to be supplemented by an account of the methods of energy transport, the equation of state, the physics of opacity and nuclear reactions, all of which will be introduced in detail.

Approximate solutions of the equations will be described. Polytropic gas spheres, homology principles and the virial theorem will be presented. The evolution of stars will be discussed, starting from their formation, evolution along the main-sequence, followed by the stages in which various nuclear fuels are exhausted and leading to the final outcome as white dwarfs, neutron stars or black holes.

Throughout the course, references 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.

Time permitting, there will be a brief discussion of stellar rotation, mass loss from stars, asteroseismology and possibly an introduction to binary stars.

Prerequisites

A very basic understanding of the principles of hydrodynamics, electromagnetic theory, thermodynamics, quantum mechanics, atomic and nuclear physics, although a detailed knowledge of all of these is not expected.

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 Strusture and Evolution of Stars* World Scientific, 2019.
2. Kippenhahn, R. and Weigert, A. *Stellar Structure and Evolution, Second Edition*, Springer-Verlag, 2012.
3. Padmanabhan, T. *Theoretical Astrophysics, Volume II: Stars and Stellar Systems*, CUP, 2001.
4. Prialnik, D. *An Introduction to the Theory of Stellar Structure and Stellar Evolution*, CUP, 2000.

Additional support

Four examples sheets will be provided and four associated examples classes will be given. There will be a one-hour revision class in the Easter Term.