Astrophysics 3, Semester 1, 2011–12

Observational Astronomy & Physics of Stars and Nebulae

Philip Best

Room C21, Royal Observatory; pnb@roe.ac.uk

www.roe.ac.uk/∼pnb/teaching.html

Synopsis

In this semester, students are introduced to the basic concepts of observational astronomy, including quantitative measures of light, stellar classification, and the principals of astronomical observations. The course then concentrates on the physics of stars and their influence on their galactic environment. The basic observational properties of stars are reviewed, followed by a discussion of the physical structure of stars on the Main Sequence, and their evolution to their final states as exotic objects: white dwarfs, neutron stars, and black holes. The interactions of stars with their surroundings are described, and the physics of the resulting ionized interstellar medium is also discussed.

Learning Outcomes

Upon successful completion of this course, it is intended that the student will be able to :

- Understand the physics behind the colour-magnitude diagram of stars.
- Describe the physics of stellar structure, and apply hydrostatic equilibrium and radiative diffusion equations to get physical conditions and timescales.
- Explain a star's energy production source and process, and describe how energy is transported out of a star.
- Derive the equation of state of degenerate gas and describe the degeneracy pressure and support of white dwarfs and neutron stars.
- Explain photoionization equilibrium, estimate the Strömgren radius and describe how the temperature and density of the intergalactic medium are measured.
- Describe fluid dynamics equations, derive the sound speed and shock jump conditions, and explain the impact of stellar winds and supernovae on the intergalactic medium.
- Correct for the effect on light of interstellar dust and the earth's atmosphere.

Schedule of lectures, problem classes and tutorials

Lectures will be held on Tuesdays and Fridays at 12.10 – 13.00 in the ROE lecture theatre, in weeks 1-11. Problem-solving sessions (which will have a variety of formats) will be inter-mingled with the lectures in these slots. Tutorials will be on Mondays at 11:10 – 13:00 in JCMB (Room 5326), on a fortnightly basis, in weeks 3,5,7,9,11.

Lecture notes and tutorial sheets will be available on-line at **www.roe.ac.uk/∼pnb/teaching.html**. Solutions to tutorials will be posted there 2-3 weeks after the tutorial.

Assessment and Feedback

The course is assessed (jointly with the Semester 2 work) by an end-of-year examination only. There will be opportunities for feedback on progress in all of the tutorial sessions. In particular, associated with each of the tutorial sheets there is a hand-in question. This is not assessed, but if handed in no later than the Friday lecture preceeding each tutorial then it will be marked and full feedback given during the tutorial on a one-to-one basis.

Syllabus

1. Observational Astronomy
   - Measuring light, colour and temperature
   - Stellar classification and the Hertzsprung-Russell diagram
2. Stellar equations
   - Hydrostatic equilibrium
   - Energy generation in stars
   - Radiative diffusion
3. Main Sequence Stars
   - Mass–luminosity relation
   - Convection
   - Upper and lower mass limits to main sequence
4. Post Main Sequence Evolution
   - Degenerate stars
   - Occupation numbers, critical densities, equation of state
   - Chandrasekher limit and compact stars
5. The Interstellar Medium and HII regions
   - Extinction
   - HII regions: ionisation and Strömgren Spheres
   - Temperature and density of the ISM
6. The Dynamic Interstellar Medium
   - Fluid dynamics and sound waves
   - Shocks; stellar winds; supernovae

Recommended reading

The course notes will provide all of the basic material for the course. There is no single book which covers well the course material at the correct level, but many make useful reference:

A.C. Phillips, *The Physics of Stars, 2nd ed., Wiley*, provides an excellent description of the stellar aspects of the course. The first Chapter is especially worth reading in detail.

J.E. Dyson & D.A. Williams, *The Physics of the Interstellar Medium, 2nd ed., IoP* provides a clear description of the ISM part of the course, and covers much more material than we can.

D.A. Ostlie & B.W. Carroll, *An introduction to Modern Stellar Astrophysics*
D.E. Osterbrock, *Astrophysics of Gaseous Nebulae and Active Galactic Nuclei*
R.C. Smith, *Observational Astrophysics*
L. Spitzer Jr, *Searching Between the Stars*
H. Scheffler & H. Elsasser, *Physics of the Galaxy and Interstellar Matter*
R.J. Tayler, *The Stars: Their Structure and Evolution*