NASSP OT1 Course Outline & Syllabus

Observational Astronomy 1: Optical & Infrared Astronomy

– 2012 –

Course Outline

The aim of this course, which comprises nominally of 20 lectures plus associated practicals and a project, is to give a *general introduction* to optical and infrared observational astronomy, emphasizing the instrumentation and techniques used. This includes discussion of basic telescope optics and design, active and adaptive optics, techniques for light detection and the principles and practices employed in photometry, spectroscopy and polarimetry. Particular emphasis is given to real instrumentation used at the Sutherland observatory site of the SAAO, including the Southern African Large Telescope (SALT) and its instruments.

Illustrated examples are given of the different types of science achieved by various astronomical instruments and techniques. Practicalities of observing and reducing astronomical data are also introduced in the course. The concept of the *Virtual Observatory (VO)* is presented, which includes a tutorial session in the NASSP computer laboratory using various VO tools. Similarly, how users apply for observing time with SALT and define their observational requirements using the various observation simulation software tools, is presented together with a hands-on tutorial session.

Course Assessment

A written examination at the end of the semester will make up 50% of the course assessment.

A project, comprising 35% of the assessment for the course, will be completed over ~ 8 weeks. In 2010 this will involve researching and writing a SALT observing proposal to address a specific astronomical question. The project will include a written report, oral presentation and submission of the proposal using the relevant proposal tools. Two or three tutorials on how to use the proposal tools will be held in support of this.

Some practical data reduction exercises and a short project based on the Virtual Observatory exercises will comprise 15% of the assessment.

Syllabus

The lectures will cover the following major topic areas (number of lectures and lecturer's initials are included in parentheses, where DB = David Buckley, SB = Sudhanshu Barway, DB = David Gilbank, PAW = Patricia Whitelock, SBP = Stephen Potter):

- **Observing Basics (2 x 1h lectures; DB)**

Astronomical coordinate systems; spherical trigonometry; precession & nutation; parallax; proper motions; stellar aberration; atmospheric diffraction and dispersion; time systems.

- **Telescopes (4 x 1h lectures; DB)**

Basic optics; aberration theory; telescope parameters and configurations; telescope lenses, mirrors, tubes, mounts, domes and enclosures; mirror coatings; active and adaptive optics (A-O); optical nature of the Earth's atmosphere, Fried parameter and structure parameters; Optical and Modulation Transfer Functions; Strehl ratio; science with AO; modern large telescopes; the Southern African Large Telescope (SALT).

- **Detectors (2 x 1h lectures; DB)**

The human eye; the magnitude scale; photographic techniques; photoelectric effect; photomultiplier tubes; image tubes; microchannel plates; semi-conductor basics; CCD principles; CCD design and

operation; noise sources and signal to noise equation; cosmetic defects; practicalities of CCD data reductions; demonstration of CCD operation.

- **Photometry (1 x 1h lecture; DB)**

Absolute and bolometric magnitudes; colour index; blackbodies; filters and photometric systems; spectral energy distributions; two-colour diagrams; dust extinction and reddening; line blanketing; colour-magnitude (C-M) diagrams; atmospheric extinction, absorption and emission; reducing photometric data; differential photometry; Fourier theory and period analysis.

- **Spectroscopy Principles (1 x 1h lecture; DB)**

Early history; dispersion and prisms; objective prism spectroscopy; diffraction gratings, the grating equation and grating parameters; échelle gratings; grisms; volume phase holographic gratings (VPHGs); spectrometer design, collimators and cameras; spectrograph examples including the SALT RSS; slit effects; CCD gain and digitization; signal to noise calculations; sky background.

- **Virtual Observatory (1 x 1 h lecture; SB)**

Definition of the VO; VO tools; VO examples.

- **Near Infrared Techniques (1 x 1h lecture; PAW)**

Challenges posed by observing at infrared wavelengths and how they are dealt with; infrared detectors and photometers and their use on the various telescopes at Sutherland. A detailed discussion of why we bother with observing at infrared wavelengths, given how difficult it is.

- **Polarimetry (2 x hh lectures; SBP)**

Polarization; Stokes parameters; observing methods and data analysis; HIPPO: the new SAAO polarimeter; spectropolarimetry.

- **Astronomical Data Reductions (4 x 1h lecture; DG)**

Different types of observations, reduction methods and resources available; CCD data reductions and the tools; FITS data format; errors and signal-to-noise (S/N); photometric reduction methods and calibrations; astrometry and source detection; the IRAF data reduction package. Practical exercises in reducing real data.

- **SALT (1 x 2h lecture; DB)**

Overview of SALT design principles; the SALT operational model; SALT first generation instrument; construction and commissioning history; future instruments and developments; SALT proposal tools. Tutorial(s) on using proposal tools and writing a SALT proposal.

Lecture Resources

Lecture notes and PDF copies of the lecture presentations are available on the NASSP website for *most* of the OT1 lectures. See http://www.star.ac.za/resources-david-buckley

Most of this material pertains to the 2010 course, but is still mostly relevant. Updates will be provided during the semester.