Course Title: **Observational Techniques 1: Optical and Infrared Astronomy**
Course Lecturer: **Dr Rudi Kuhn (SAAO/SALT)**
Course credits: **1**
Lecturer contact hours: **24**
Tutorial/practical hours: **6**

1) Course overview:
The aim of this course, which comprises nominally of 20 lectures plus associated hands-on exercises and projects, is to give a general introduction to optical and infrared observational astronomy, emphasising 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 and spectroscopy. Illustrated examples are given of the different types of science achieved by various astronomical instruments and techniques. The practicalities of planning and conducting observations, as well as the reduction of astronomical data and data reduction software are also introduced in the course. Ethics surrounding aspects such as telescope time and publications are also covered. Particular emphasis is given to get practical experience on data reduction and analysis through various laboratory sessions.

2) Course breakdown/syllabus:

- **Observing Basics (3 x 1h lectures)**
  Astronomical coordinate systems; spherical trigonometry; precession & nutation; parallax; proper motions; stellar aberration; atmospheric diffraction and dispersion; time systems.

- **Telescopes (2 x 1.5h lectures)**
  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

- **SALT (1 x 1h lecture)**
  The Southern African Large Telescope (SALT).

- **Detectors (2 x 1.5h lectures)**
  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 (2 x 1h lectures)**
  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 2h lectures)**
  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.

- **Near Infrared Techniques (1x 1h lecture)**
  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..

- **Applying for Telescope time and ethics in Astronomy (1 x 1h lecture)**
  Overview of how to apply for telescope time. How to write and plan good proposals. Time allocation committees. Ethics surrounding publications and telescope time. Conflicts of interest. Plagiarism.

- **Linux and other software in the astronomical context (1x 1h lecture)**
  The Linux operating system; Command-line navigation and automating tasks with scripting; Text editors and manipulating text files with unix programs; Display and management of FITS files; DS9 FITS viewer and applications. Python modules.

- **Astronomical Data Reduction (1 x 1h lecture)**
  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).

- **A. Photometric Data Reductions (2 x 2h lab)**
  Photometric reduction methods and calibrations; astrometry and source detection; the AstroImageJ data reduction package. Practical exercises in reducing real data. Creating false-colour images from images taken with multiple filters.

- **B. Spectroscopic Data reductions (2 x 2h lab)**
  Spectroscopic reduction overview; data reduction methods; Wavelength and flux calibrations; the IRAF data reduction package. Practical exercises in reducing real data.

3) Resources:
Lecture slides will be provided that draw upon a variety of resources including textbooks and online material. There is no prescribed textbook, but useful textbooks may include Foundations of Astronomy (Seeds & Backman) and An Introduction to Modern Astrophysics (Carroll & Ostlie).

4) Breakdown of practicals/tutorials:
Labs will cover photometric data reduction and basic spectroscopic data reduction. Real data from SALT and other international facilities will be provided for students to process and analyse.

5) Additional skills to be developed during the course:
How to write a good telescope time proposal; Linux operating system use and unix scripting; Manipulation of text data; basic usage of the AstroImageJ package for reduction of astronomical data; displaying and manipulating FITS data; Python module usage in astronomy; Virtual observatory tools to access data from telescope archives and other online databases.

6) Assessment
The course will be assessed by 3 assignments each counting 20% of the final grade and a data reduction practical that will make up the final 40% of the final grade.