S261 Optical Astronomy

S261.1 Aim of the Experiment

The aim of the lab course is to introduce into modern oberserving and data reduction techniques in optical astronomy. In the first part you will reduce provided data from the 1m-Cassegrain telescope from the Hoher List observatory which contains multiple lensed quasars due to the gravitational lensing effect. After calibrating and analyzing the data a good guess of the Hubble constant H_0, a fundamental cosmological parameter with which you can calculate distances in the Universe, can be obtained. In the second task you will observe an exoplanet transit using the 50cm Cassegrain-telescope on the roof of the AIfA, also reduce this data and extract a light curve of the transit. If the weather is not good enough, you will analyze some characteristics of our CCD camera.

S261.2 Required Knowledge

The requirement for a succesful carrying out of this experiment is basic knowledge about astronomy like they are taught in both introduction to astronomy courses in Bonn. Students without this knowledge are welcome but have to count in more time for preparation. Furthermore you have to know about:

- Cosmology: Expansion of the Universe, Hubble constant, distances
- Gravitational lensing: lens equation, geometry of strong lensing, creation of multiple images, basic concepts like Einstein angle, lens potential etc.
- AGNs (Active Galactic Nuclei): Basic properties, rough structure
- Time-delay measurements: Estimation of the Hubble constant through time delay, minimum dispersion method, SIS model and properties
- Basics about observations: Structure of a (Cassegrain-)telescope, telescope resolution, different coordinate systems, star time and hour angle, magnitudes, airmass, seeing, used filters in optical astronomy
- Properties of CCD detectors: types of CCD detectors and their properties, principle of charge transfer, noise, quantum efficiency, saturation level, linearity, gain
- Data reduction: bias, dark, flat, superflat, astrometric and photometric calibration, coadd (stacked) images

Furthermore elementary knowledge of Linux are neccessary, e.g. shell commands like ls, cd, cp, mv, rm, mkdir etc.

S261.3 Literature

- Script (**can be borrowed from your tutor**)
- Basics:
  - P. Schneider: *Extragalactic Astronomy and Cosmology: An Introduction* Springer, 2007.
- Gravitational lensing, cosmology:
  - P. Schneider: *Extragalactic Astronomy and Cosmology: An Introduction* Springer, 2007.
  - P. Schneider: *Introduction to Gravitational Lensing and Cosmology*
    `http://www.astro.uni-bonn.de/~peter/SaasFee.html`
- Astronomical observations and data reduction:
  - M. Schirmer: *Principles of CCD data reduction*
    `http://www.astro.uni-bonn.de/~mischa/mbo/datareduction/index.html`
  - S. Howell: *Handbook of CCD Astronomy*, 2000, Chapters 1 - 5.
    especially chapter 2 and 3
  - THELI user manual Chapters 3 - 4, 6 - 12, and App. A - C and F:
    `ftp://ftp.ing.iac.es/mischa/THELI`
    especially chapter 3
  - C. Peng: *Galfit quick start* (manual):
    `http://www-int.stsci.edu/~cyp/work/galfit/README.ps.gz`

Please get the lab course script at least 2 weeks before your oral exam from your tutor. It's not expected that you read both manuals completely (THELI and galfit), but during the experiment they can be very helpful. Both and the *Handbook of CCD Astronomy* can also be borrowed from your tutor.

S261.4 Assignments

This experiment consists of three parts: The first part (data reduction) will be performed over day, the second part (observations of an exoplanet transit) will be perfomed over night (talk to your tutor about this!). Afterwards you will reduce and analyze this data (part three).
First part:

1. Step-by-step data reduction and calibration of an existing data set with the THELI package
2. Flux and (angular) diameter distance of the multiple lensed quasar images from the coadded image

3. Mesuaring the Hubble constant and other physical parameters

Second part:

1. Get familiar with the telescope and its controls, setting up an observing schedule
2. Observing an exoplanet transit
3. Bad weather tasks: Mesuaring the linearity and full well capacity of the CCD

Third part

1. Reducing and analyzing the exoplanet transit data as learned in part one.

S261.5 Procedure and analysis

The details of the experiment are written in the script.
Please note that part two of this experiment has to be carried out during night. For the observation we need good or very good weather (for Bonn). You will decide on some possible days with your tutor and he or she can tell you about 24 hours before the observation if it will take place or not (due to changing weather conditions). In the case that you have bad luck and there is no clear night, you will have to do the bad weather tasks.

Best wishes for a successful experiment! Stand: January 2019