Special Course in Observational Astronomy

Fall 2019
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Course Information

• Instructor: Clif Kirkpatrick
• Mondays in Physicum D210 from 14:15 to 16:00
• Website:
  • https://wiki.helsinki.fi/display/ckirkpatrick/IRAF+Data+Reduction+for+Imaging+and+Spectroscopy
Overview

• IRAF (Image reduction and analysis facility)
  • Basics of IRAF commands and packages
  • Basic and advanced image reduction
  • Data calibration
  • Photometric source extraction
  • Spectra extraction and modeling

• Good habits

• Preparation for NOT Observing school
  • Advanced Course in Observational Astronomy I
  • November 4 – 9
“NOT School”

• This course is a prerequisite for Advanced Course in Observational Astronomy I

• Description:
  • This is a national course on advanced observational astronomy, in which astronomy students from all over Finland participate.
  • The course involves an intense week at Tuorla Observatory (food and accommodation is covered), when remote observations using a 2.6 meter telescope at La Palma will be conducted.
  • After that the students apply their knowledge of data reduction obtained during IRAF course and work in groups to prepare a presentation of their results. Individual reports describing the data acquisition and data reduction are used to form the final grade in January 2019.

• Instructors are responsible for enrolling students into this course
“NOT School”

• Travel to Tuorla Observatory will be reimbursed by the graduate school, but you will have to make the arrangements yourself.

• Matkahuoito bus stops right in front of the observatory.
  • 6:50 – 9:15 Helsinki to Tuorla on November 4th
  • It’s okay to wait to book, but I will remind you again later in the course

• Dormitory rooms are provided for the entire stay, as well as breakfast, lunch, dinner, and some night snacks.

• No official schedule yet, but I will announce it as soon as I know.
Materials

- “A User's Guide to CCD Reductions with IRAF”
- Can be found at:
  - http://iraf.noao.edu/docs/recommend.html
- ALFOSC and NOTCAM cookbooks
  - http://www.not.iac.es/observing/cookbook/current/
- In class slides/tutorials on website
Class work

• Currently I am unsure how to access an IRAF install from university computers
• Tutorial will cover topic of discussion
• Exercises will be assigned each session with unfinished work expected to be completed as homework
• Additional work may be assigned depending on topic and time
• Final grade is Pass/Fail based on participation and completion of these tasks
## Schedule

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Not School introduction

• We will not have a regular class next Monday, instead the professor for Observational Astronomy I (Alexis Finoguenov) would like to hold the first meeting for students wanting to take this course
• What are you availabilities for 19.9 or 20.9?
Download data

• A link on the course website
• Starting next lecture, I will email before the class which files need to be downloaded before the lecture
• Todays files: download folder ‘lectureOne’
  • `wget fileAddress` (Right click link on webpage, select “Copy Link Location”)
  • `tar –xvzf lectureOne.tar.gz`
• Should look like: `$ ls lectureOne/`
  • `bias.fits`   `flatfield_raw.fits`   `image_raw.fits`
IRAF Installation

• Ureka
  • Collection of useful astronomy software
  • http://ssb.stsci.edu/ureka/
  • Download the installer to desired directory
    • Run: $ sh install_ureka_*
    • Give permission to edit your login scripts
  • Restart your terminal window
    • Launch: $ ur_setup
    • Alternatively: double-click Ureka desktop icon if available

Or
  • May need to install DS9 separately: http://ds9.si.edu/site/Download.html
**IRAF first time setup**

- Create working directory
  - `mkdir directoryName`
- Within the directory make a new IRAF instance
  - `$ mkiraf`
    - Enter terminal type: `xgterm`
- Should now see `login.cl` and `uparm` folder in your working directory
Edit login.cl

• Only need to make one basic edit, but there are others you could consider later
• Uncomment
  • set stdimage
• Change Value to
  • imt2048
IRAF startup

• Start IRAF: $ cl
  • Navigate the packages simply by typing the name
  • Try: noao -> imred -> ccdred
  • > help taskName gives documentation
  • Edit parameters: > epar taskName
    • Some commands
      • :wq --- save and quit or press ctrl-d (ctrl-c to quit without changes)
      • :r! --- reloads current presets
  • Execute task by typing its name (or :go from epar screen)
  • To logout: lo

• Start IRAF: $ pyraf
  • Execute same commands
  • Notice a difference?
  • To logout: > .exit
Astronomical data

• FITS
  • Flexible image transport system
  • Most commonly in the format of data array + header
    • Metadata stored as ASCII header
  • Can be much more though
    • Spectra
    • Photon list
    • Data cube
    • Multi-table database

• DS9 common viewer for images
• TOPCAT common viewer for tables
Exercise: DS9 basics

• Open the file image_raw.fits
  • $ ds9 fileName &

• Following along with the demonstration:
  • Scale: try min max + log, try zscale + linear/power
  • Zoom: to fit
  • Color: play with what you feel looks best to you
  • Edit: none
  • Hold right click: adjust scale/stretch
  • Frame: new -> File, Open... select bias.fits, do the same for flatfield_raw.fits
    • Try single, tile, blink, etc.
  • File -> Display Header, see meta data associated with an image, some files have more than one
Exercise: Basics of Image Reduction
Instrument parameter

- IRAF installation on university machines/servers are missing an important parameter file
- This should not be an issue for personal installations from ureka
- Go to: > noao -> imred
- > epar ccdred
  - (instrument): "ccddb$kpno/camera.dat"
CCD Bias

• Every frame of data needs the bias removed as the first step
• At this point we will also trim the unused portion of the CCD
• The bias is the inherent charge in the CCD pixels
• Take a series of zero second exposures allows you to create a master bias frame to be removed from every image taken that night
Make bias correction with ccdproc

• Go to: > noao -> imred -> ccdred
• > epar ccdproc
• First step, set all Yes/No questions to NO
• Parameters to edit:
  • images: image_raw.fits[1] ← Raw file must include extension!
  • (output): b-image.fits
  • (ccdtype): ← Set this field to blank
  • (trim): Yes
  • (zero): Yes
  • (trimsec): In the format (area to include) -> [x1:x2,y1:y2]
  • (zero): bias.fits ← Formatted file
• Follow the exact same procedure for flatfield_raw.fits
Flat field image

• Sensitivity variance, optical anomalies, and illumination variations must be accounted for.

• “Sky flats” can be taken in the late evening/early morning. The sky after sunset is approximated as a uniformly illuminated source.

• “Dome flats” are similar, but instead you image the inside of the dome illuminated by lamps. This can be done at any point of day or night.
Correct flat field with ccdproc

• > epar ccdproc
• Again, set all Yes/No questions to NO
• Parameters to edit:
  • images: b-image.fits
  • (output): fb-image.fits
  • ccdtype: \(\rightarrow\) Set this field to blank
  • (flatcor): Yes
  • (flat): b-flatfield.fits
Results

• The final image is the bare minimum that must be done to have an image that can be considered science ready.
• Is the background low? Is it mostly uniform?
• Blink the first and final images to illustrate the change after data reduction
Homework: Get IRAF working

• Attempt to install IRAF/DS9 in some way on your personal laptop. This will be useful for the observing school, as there aren’t any provided computers for data reduction.