Astronomy 5830 – Observed Properties of Astronomical Systems

Autumn Semester 2017

Homework #2 – Due September 25, 2017

Complete this problem set in a jupyter notebook with sciserver.org and hand in a printout of your notebook. One way to print a notebook is to use File > Download as > PDF via LaTeX to produce a PDF you can print. Please be sure to annotate your work, such as by changing from Code to Markdown for specific cells.

1. Signal-to-Noise: An interesting object has been discovered with r_{AB} = 22 mag and you would like to observe it further. Note that the SDSS r-band has λ_c= 0.626μm, $d\lambda$ = 0.1064μm, and the zeropoint of the AB magnitude system is 3631 Jy.
    a. What is the flux zeropoint per unit wavelength f_λ? Please use erg s^{-1} cm^{-2} A^{-1}.
    b. What is the zeropoint in photons s^{-1} cm^{-2} A^{-1}?
    c. How many r-band photons are incident on one of the LBT's 8.4m diameter primary mirrors per second? Ignore atmospheric absorption.
    d. Read through the online MODS1 Instrumental Sensitivity[1] document. Use those data to calculate the ADU/s expected from this object in *imaging mode*. Assume airmass X=1.
    e. Use your results from (c) and (d) to estimate the total system throughput (atmosphere + telescope + instrument). Identify and provide a quantitative discussion of the main contributors to the throughput. A short paragraph should suffice.
    f. How long do you need to integrate to achieve about S/N = 10 per pixel? Ignore sky brightness.
    g. It is near full moon so the sky brightness is r_{AB} = 21 mag per $arcsec^2$. The seeing is 1", so you have chosen a 1.5" radius aperture. What is the S/N in 10s?
    h. Under these sky conditions, how long do you need to integrate to achieve the same S/N ratio you originally estimated in part (f)?
    i. A week later you are able to obtain a spectrum with the dual grating mode under dark conditions (r_{AB} = 22 mag per $arcsec^2$). How long do you need to integrate to get S/N = 5 per pixel in your spectrum? Use the 1" slit and assume no slit losses. Round your exposure time to the nearest minute.
2. Data exploration with sciserver.org and SDSS. Use sciserver.org and a jupyter notebook to identify the following data and produce the following figures. You are encouraged to use published catalogs to help focus your search, just be sure to cite any references you use.
    a. Identify an open or globular cluster in the SDSS footprint and plot an r vs. g-r color-magnitude diagram for the cluster. Make sure you choose a cluster with an obvious main sequence and giant branch.
    b. Identify an RR Lyrae star in the Stripe 82 region and plot a phased, g-band light curve based on SDSS photometry. I encourage you to identify and use a catalog of known RR

[1] http://www.astronomy.ohio-state.edu/MODS/ObsTools/Docs/MODS1_InstSens.pdf

Lyrae stars to choose one with a known period, although there is an implementation of the Lomb-Scargle algorithm within astropy.stats (and another in scipy).

c. Identify a cataclysmic variable star with an SDSS spectrum. Plot the spectrum and label several of the most prominent emission lines.

References and hints for #2:

The SDSS Schema Browser http://skyserver.sdss.org/dr12/en/help/browser/browser.aspx describes the tables (and views) in the SDSS database.

The SDSS Navigate Tool http://skyserver.sdss.org/dr12/en/tools/chart/navi.aspx is a useful way to view objects in the SDSS footprint and determine their angular extent.

There is a Glossary of SDSS-III Terminology https://www.sdss3.org/dr10/help/glossary.php that describes many of the columns in the tables, as well as other terms.

SDSS SQL Tutorial: http://skyserver.sdss.org/dr12/en/help/howto/search/searchhowtohome.aspx

The astroml.org site http://www.astroml.org/examples/datasets/index.html contains many examples of how to use AstroML tools to retrieve and process SDSS data.