Astrophysics Module of the Rm4 Seminar at Castilleja School

0. Overview

Science overview (Raja)

- Andromeda Galaxy
- Hubble MCT programs
- PHAT: brief overview (students will read JD's paper later)
- Clusters: stars likely born at similar times from a similar environment

Design of this class (Claire)

- Work in groups on open-ended activities that increase in both level of ownership and scientific importance
- Application to careers in other fields:
  - Programming
  - Reading papers

1. Predicting Cluster Appearance from Color-Magnitude Diagrams (Led by Claire)

Goals: Difference between magnitudes, flux and color; reading a CMD; running Python scripts with variable inputs; editing plotting commands

Lecture

- Use projector to show color images of ten clusters
  - Vocabulary: "red" (actually yellow) vs. "blue"
  - Observation: bright stars and faint stars
      - Multiplot diagram: color images of all 10 clusters, without names
- Magnitudes and Colors
  - Measure brightness of stars through each filter in counts
      - Colored cellophane for "filters" concept
  - Convert to mags (logarithmic unit) - show equation
  - Color: difference in mags between filters
- CMD
  - Axes
  - One dot for each star

Task: Predicting Appearances

- Use plot_cmd.py to make a CMD of any cluster from the list. Use your CMDs to predict in as much detail as you can the size, color, and brightness of each cluster.
  - *Facilitation note: Lead students to change point sizes to represent color, flux and magnitudes.*
  - *Facilitation note: Allow students to consider the possibility that a cluster need not be a single color.*
    - plot_cmd.py: version that only makes one plot at a time. Include cluster names.
    - FITS .phot and .skyphot files
- Compare your predictions to Cliff's color images.
    - Printout of ten-cluster plot from projector, with names

Wrap-up: Summarize on the board the properties of the CMD that influence color, brightness and size. List the blue clusters, red clusters, and blue clusters with bright red stars. List the brightest clusters. Keep these lists for the Spectra unit.

2. Spectral properties (Led by Raja)

Goals: Spectra and photometry yield complementary information; reading 1D spectra

Lecture: 1D spectra

- Units
- Creating a spectrum: Slitmask and spectrograph
    - Bring DEIMOS slitmasks
- Noise; S/N ratio
- Artifacts: chip gap, telluric and scattered light

Task 1: Smoothing

Task 2: Artifacts

- Edit plot_spectra.py to plot lines on each spectrum denoting the wavelength ranges of the chip gap, telluric and scattered light.
    - *Facilitation note: Students should realize that these wavelength ranges are slightly different for each spectrum. This will give them practice with for loops.*
        - plot_spectra.py, with code IDs (zspec1d names)
        - zspec1d files

Task 3: Classifying spectra

- Compare the 10 cluster spectra to library spectra to describe their temperatures, brightnesses and abundances.
- Compare classifications to those from Unit 1. Do you notice anything funny?
    - *Facilitation note: Students should notice that at least one cluster appears redder than it should.*
    - Template spectra from Miles library, labeled with temperatures, magnitudes and metallicities

Wrap-up" List properties that can be inferred from photometry, and properties that can be inferred from spectra. Discuss any apparent discrepancies. Discuss effect of dust.

2D spectra - raw spectra of ten clusters

Reading Assignment (Claire): At the end of the first day (which could be after Unit 1 or somewhere in the middle of Unit 2), each group of 5 students (one from each programming group) will be assigned a paper to read. At the second class meeting, each group of five will present that paper.

Using NASA/ADS

Tips for reading papers: Intro, abstract, conclusions, wikipedia, skipping unfamiliar words, using diagrams

Paper 1: Dalcanton et al. 2012 (PHAT survey overview -- assign just a portion)

Sect. 1: Intro

Sect. 2: Background

Sect. 3: Survey design - only 3.1, 3.2 and 3.6
Sect. 4.5: Crowding and depth
Sect. 5.1: CMDs
Sect. 6: Conclusions

Paper 2: Johnson et al. 2012 (Year 1 Clusters overview)
All, except for appendices

Paper 3: Beerman et al. 2012 (Stochasticity)
All

3. Estimating age and metallicity of clusters from isochrones

Goals: Isochrones, uncertainties, incompleteness; reading in text files; adding lines to plots; comparing models to data

Lecture (Raja)

- Anatomy of a CMD: red giant branch, main sequence, main sequence turnoff
- Isochrones
  - CMD track for a single age, metallicity and reddening
  - Theoretical predictions: web interfaces
  - Apparent vs. absolute magnitude
- Incompleteness in the PHAT survey
  - Star counts of objects fainter than the incompleteness limit are not reliable
  - Depends on crowding
- This part of the seminar is original research -- it has not been done before!

Task 1: Which stars in your chosen cluster are below the incompleteness limit?

- Copy plot_cmd.py to plot_isochrones.py
- Find the incompleteness limit in Dalcanton et al. 2012
- Plot the incompleteness limit on the CMD of a single cluster
  - *Facilitation note: Students may need to find the distance of the cluster.*

Task 2: Estimate the age, metallicity and reddening of a cluster

- For any cluster, estimate the age, metallicity and reddening of the cluster using Padova isochrones.
  - *Facilitation note: Students should end up with a possible range of parameters.*
  - *Facilitation note: Students should understand the effect each parameter has on the track of the isochrone. They may want to use logic (color, evidence of reddening) to constrain their initial guesses.*
  - *Facilitation note: Make sure students come to the realization that they cannot use the part of the isochrone below the incompleteness limit.*
    - Example code for reading text files.

Wrap-up (Claire): Convene with another group (who worked with a different cluster) to discuss the effects each parameter has on the isochrone track. *Possible additional wrap-up: note* *that the shape of the CMD is influenced by the age and metallicity of the background, and students are welcome to investigate that for their independent project.*

Reading: Fouesneau et al. 2013, submitted

4. Group projects

This section is not well defined yet, but students will ask their own research question (with help, or at least approval, from us) and work on it in the third and fourth class meetings. They will present their projects in the last hour of the fourth meeting.