Homework 5

Stellar Pulsations

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Today we'll be exploring a real, multi-band light curve from the Zwicky Transient Facility (ZTF) of a RR Lyr star, and recovering its strongly periodic signal. This process is exactly that new RR Lyr (or other periodic variables) can be discovered in time domain surveys!

We'll then use a large catalog of detected RR Lyr stars in ZTF to compute your own "Period–Luminosity Relationship" (AKA the "Leavitt Law"). This correlation allows us to estimate the star's distance simply from its measured pulsation period, which is a powerful method to accurately constrain stellar distances even out to nearby galaxies.

The work in this assignment is guided by the provided Jupyter Notebook file:

`RRLyr_Period-Luminosity.ipynb`

which gives you lots of helpful code to use, and has the specific prompts for plots and calculations to make.

You will need two data files:

`12.parquet` – a multi-band light curve from ZTF for a single RR Lyr star

`rrl_main_cat.csv.gz` – the RR Lyr catalog from Huang & Koposov (2022)

which the Notebook demonstrates how to read and use.

Part 1

(30pts)

Go through Part 1 of the notebook, reading the ZTF light curve and measuring the periodic signal using the Lomb-Scargle Periodogram tool built into Astropy.

Plots to make:

- 3-band (g, r, i) light cure for the RR Lyr star
- The r-band Lomb-Scargle Periodogram for this RR Lyr star
  - Be sure to identify and label the "strongest" period (the highest peak in the periodogram)
- Plot the phase-folded (or period-folded) light curve for this RR Lyr star in all 3 filters.

Part 2

(20pts)

Go through Part 2 of the notebook, reading the RR Lyr catalog from Huang & Koposov (2022), and building your linear Period – Luminosity relationship.

You'll need to compute the *absolute* r-band magnitude for every RR Lyr in the provided catalog, including the correction for dust extinction that is provided as $E(B-V)$. You can compute the extinction correction in the r-band for every star in magnitude units using this

standard formula: $\Delta mag = A_r \times E(B-V)$. Remember that a large extinction should result in a large *negative* magnitude correction!

Plots to make:

- The log Period – Luminosity scatter plot, with the published relationship listed in the Notebook, and with your linear fit overlaid.

Part 3

(10pts)

Use the new Period – Luminosity relation you've created to compute the distance to the RR Lyr star that we explored in Part 1, in units of pc. Be sure to apply the extinction correction to get the proper absolute magnitude!

Turn in your write-up, including the labeled plots, as a PDF. Remember to include an attribution for any group work! Also turn in your code or Jupyter Notebook used to solve the assignment. Note: we'd like to be able to run your code to check that it actually works, so be sure (if using Jupyter notebooks) to check that it runs "top down"!

Use the Dropbox upload link. **DUE: Mar 02, 11PM PST**