Calculating potential binary stars’ periods using data from the Sloan Digital Sky Survey (SDSS)

1. Scientific background
2. Binary star

In astronomy, binary stars are 2 stars that are gravitationally bound to each other and revolve around one another. Their orbits can be either elliptical or circular, as shown in the figure below. The time in which each star in the system finishes its orbit is called the binary system’s orbital period.

This period can be measure using a star’s measured radial velocity, which is the velocity vector component that is parallel to the observer’s line of sight.

1. Sloan Digital Sky Survey (SDSS) and Apache Point Observatory Galatic Evolution Experiment (APOGEE)

The SDSS is a major astronomical survey using a 2.5m telescope at Apache Point Observatory in New Mexico, US and the Irénée du Pont Telescope at Las Campanas Observatory, Chile. Beginning its operation in 2000, the SDSS has gone through 4 phases, each comprises of multiple surveys corresponding to different goals.

APOGEE is one of those surveys. It contains two versions, which lasted from 2011 - 2014 and 2014 – 2021 respectively. APOGEE measures the chemical element abundance and dynamic motions of stars in the Milky Way. This project uses a few of APOGEE’s motion-related data fields, including radial velocity (RV).

1. Method

The project is divided into 2 major steps: detecting stars that have a high chance of being in a binary system, then calculate the orbital period of those binary stars

1. Detecting binary stars

* According to <https://www.sdss4.org/dr17/irspec/use-radial-velocities/>, we can confidently conclude that a star belongs to a binary system if the following 3 conditions are met:

+) RV’s standard deviation is greater than 1 km/s

+) RV’s standard deviation is 10 times greater than its RV error

+) It has “many” not-low-SNR and not-low-quality visits (the exact number to satisfy “many” is up to the analyst’s discretion; the higher the number, the more confident the analyst will be about the accuracy of their findings).

1. Calculate orbital periods
2. Data collection
3. Data analysis
4. Results
5. Perform an SQL query at (<http://skyserver.sdss.org/dr17/SearchTools/sql>) to find potential binary stars

* binaryStar = apogeeStar where nvisits >= 8, vscatter > 10 verr
* Tutorials: <https://www.sdss4.org/dr17/irspec/use-radial-velocities/>

1. Find the period of those stars

* Use SQL to find the visits associated with the above binary stars: JOIN binaryStar AND apogeeStarVisit WHERE star.id = starVisit.id
* Build the Lomb-Scargle Periodograms using AstroPy’s library function (<https://docs.astropy.org/en/stable/timeseries/lombscargle.html>)
* The period is the time value at max power.
* Compile a file containing: star.id; period.

1. Apply the program to allStar file
2. Write a report