ASP 5203, ESTRELLAS VARIABLES 2019-1 HOMEWORK 1.

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ABSTRACT

This homework is based on Marcio Catelan's first homework. First, I worked with the General Catalog of Variable Stars (GCVS) and its content. Second, given magnitudes for two variables stars in function of time, I compute periods of variability on the basis of empirically derived data. Third, I analyze a historical data with times of maxima for an RR Lyrae star from the GEOS database and compute O-C values assuming linear ephemeris.

Keywords: Variable stars, GCVS, VSX catalog, O-C diagram.

1. PROBLEM: THE GENERAL CATALOG OF VARIABLE STARS (GCVS) AND INTERNATIONAL VARIABLE STAR INDEX (VSX).

Here I have worked with the GCVS and VSX. These are catalogs which are a compilation of variability data that has appeared in the literature. I have worked with the updated version of GCVS (i.e., version 5.1) (updated version when this homework was done); which have been updated in April, 2019.

1.1.

As we have seen in class, variable objects may be classified according to their astrophysical origin for variability. In GCVS and VSX variable objects have been classified in: i) Eruptive, ii) Pulsating, iii) Rotating, iv) Cataclysmic (novalike explosive), v) Eclipsing binary systems, vi) Intense variable X-ray sources, vii) Other symbols and, viii) New variability types.

In this homework, I have worked with the first five types of variability (i.e., from i) to v)). Based on Samus et al. 2017 (hereafter, Samus17). paper, who used GCVS 5.1 version, I did comparasion between my estimation of number of each variability stars-objects with the paper named above. I downloaded a GCVS file that contained the data of interest, I read it and made a summary for later to be able to compare my results with the given by Samus17.

I have chosen the next type of variabilities that belongs to a certain type of variability: i) UV (Eruptive variable of the UV Ceti type) , ii) RR (variable RR Lyrae type), iii) SXARI (SX Arietis-type variables), iv) N (Novae) and v) E (Eclipsing binary systems).

The .txt file given by GCVS platform is in a not trivial to read, which caused me multiple problems. In the other hand, .csv file given by VSX was easier to read and manipulate.

1.2.

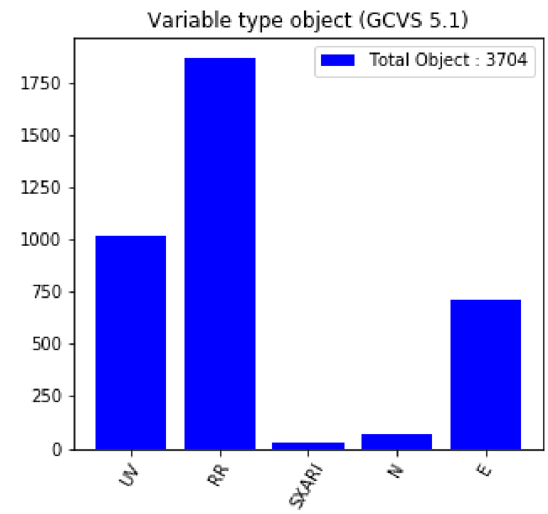

Figure 1. Histogram of variability subclasses in updated GCVS 5.1 catalog (April, 2019).

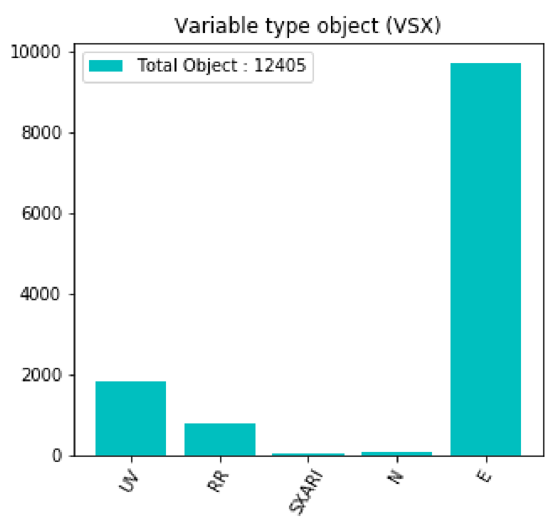

Figure 2. Histogram of variability subclasses in updated VSX catalog.

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Variable subclass	April, 2019.	Samus17
UV	1023	997
RR	1878	1440
SXARI	26	25
N	66	61
E	711	479

Table 1
Counts for variability subclasses objects in GCVS catalog; it is possible to see an increased in the count of objects in every subclass due to updated version of the catalog.

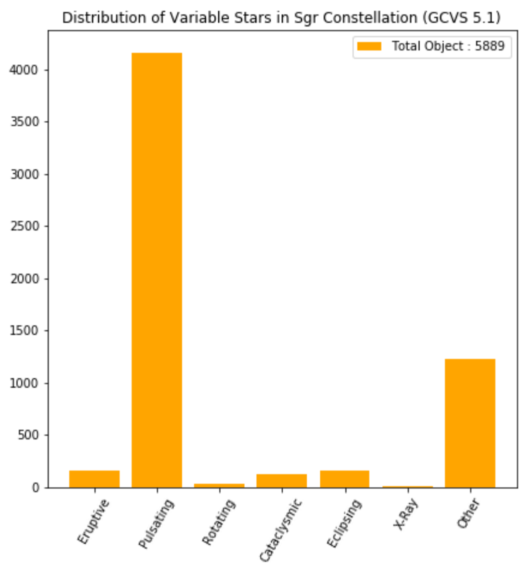

Figure 3. Distribution for Variable Objects in Sgr constellation, the constellation with the largest amount of variable objects in GCVS5.1 catalog.

The objective of this section was to find in which constellation of the GCVS data contained the largest and smallest number of variable stars, of any kind. In order to obtain this result I created a program that separate the object to its respective constellation, for coding I used `python`.
The total amount of object in the catalog is 53628.

- Constellation with largest number of variable stars: (72) Sgr : 5889.
- Constellation with smallest number of variable stars: (10) Cae : 32.

1.3.

Due to the large amount of variable type, for example DSCTC+GDOR type, is a object that present more of one type of varibility, this makes difficult to find a category in where this object belongs. So, it was difficult to separate them into every category (named in 1.1), this causes that the distribution into the various variability classes present in Figure 3. and Figure 4. are an approximation.
In both cases (Sgr and Cae) it is possible to see that the pulsating type objects are in mayority and they are follow by other type of variability.

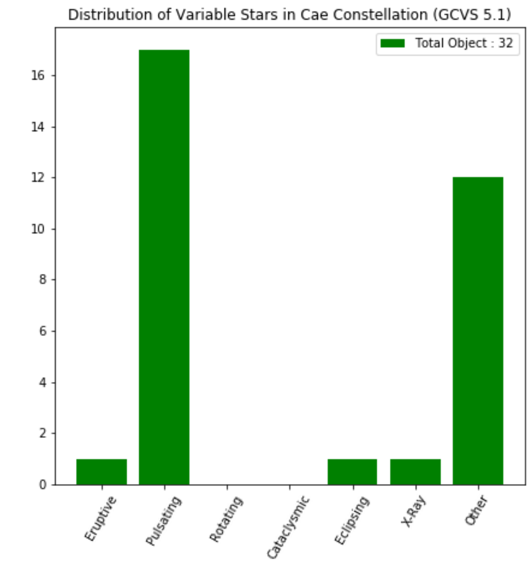

Figure 4. Distribution for Variable Objects in Cae constellation, the constellation with the smallest amount of variable objects in GCVS5.1 catalog.

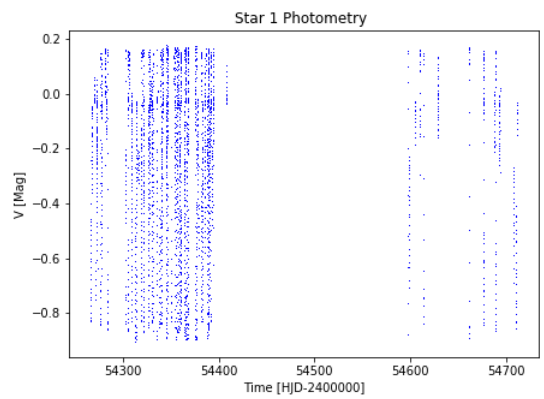

Figure 5. Photometry for object in star1.dat file, y-axis shows the apparent magnitude in V.

2. PROBLEM: MAGNITUDE AND PERIOD.

2.1.

From file star1.dat and star2.dat that contains visual photometry for two field variable stars, plot of magnitude vs. time for both stars were made (see Figure 5 and 6).

3. PROBLEM: O-C TECHNIQUE.

3.1.

This is the demostration that if a star's period changes linearly with time, the time of maximum at epoch E will be given by:

$T_E = T_0 + P_0 E + \frac{1}{2}\frac{dP}{dt} \langle P \rangle E^2$ (1)where $\langle P \rangle$ is the mean period over the whole time interval covered by the data.

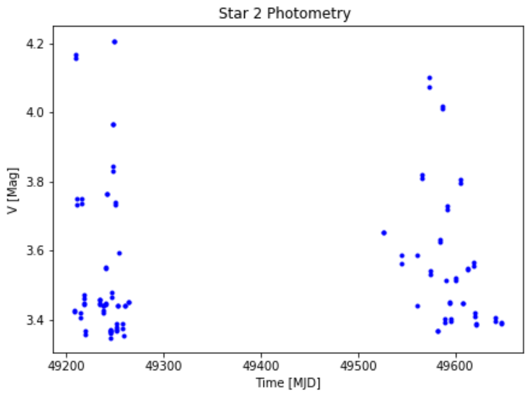

Figure 6. Photometry for object in star2.dat file, y-axis shows the apparent magnitude in V.

	Earliest Maximum	Latest Maximum
HJD	2415290.66628	2458446.8161
UT1	03:59:26.6, 28/09/1900	07:35:11.0, 24/11/2018

Table 2
Earliest and latest time of maximum available in this dataset in terms of HJD and UT1, format hh:mm:ss, dd/mm/year.

Let assume that the period changes linearly with time:

$$P = a + bt \tag{2}$$

where t is the time, and a, b are constants. Let P_0 be the period at t = 0 and $\langle P \rangle$ the average period over the whole time interval, then:

$$P = a + b \langle P \rangle E \tag{3}$$

with

$\langle P \rangle$ = a + $\frac{1}{2}$bt

So, T_E = T_0 + aE + $\frac{1}{2}$b $\langle P \rangle$E^2 (4)with P_0= 0, $\frac{dP}{dE}$= b $\langle P \rangle$ and $\frac{dP}{dt}$ = b. thus the expected time is:

$$T_E = T_0 + P_0 E + \frac{1}{2}\frac{dP}{dt} \langle P \rangle E^2$$

3.2.

The historical data (file times-of-maxima.dat) with times of maxima for an RR Lyrae star from the GEOS database was used to compute O- values assuming linear ephemeris based on the star's GCVS period, namely P_0 = 0.41986 days and T_0 = 2442582.4060 HJD.

3.3.

Earliest and latest time of maximum available in this dataset were calculated, see Table 2.

3.4.

Using these data, I obtained an estimate of the period change rate of the star, in units of days/Myr, also I estimated the error in this value.
Period change rate:

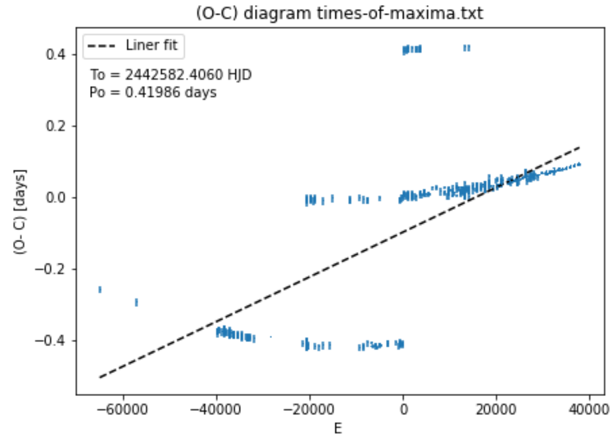

Figure 7. O-C diagram for an RR Lyrae star, from times-of-maxima.dat file. A linear approximation with parameters a_1= 6.25 *10^{-6}, a^0= -9.61 *10^{-2} (f(x) = a_1x + a_0) was fitted.

$$\frac{dP}{dt} = 1.40 *10^{-12} \pm 7.55 *10^{-16} \text{ days/Myr.}$$

This was calculated using the formula:

$$\frac{dP}{dt} = \frac{P_{max} - P_{min}}{T_{max} - T_{min}}$$

where P_{max} is the period of the latest time of maxima, P_{min} is the period of the earliest time of maxima, T_{max} latest time of maxima and T_{min}.

Note : all the programs used and codes are avaliable in Public GitHub repository.