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Description of variable stars visible in small observatories for teaching purposes

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Abstract. In this work we present a methodology to identify which variable stars of the General Catalog of Variable Stars (GCVS) can be observed in a given observatory, with a certain instrumental configuration and what is the best time of the year for observation. In order to exemplify the developed method, we present the results obtained for the Astronomical Observatory (OA) of the Federal University of Alfenas, Brazil.

Resumo. Neste trabalho apresentamos uma metodologia para identificar quais estrelas variáveis do General Catalogue of Variable Stars (GCVS) podem ser observadas em um determinado observatório, com uma determinada configuração instrumental e qual a melhor época do ano para a observação. A fim de exemplificar o método desenvolvido, apresentamos os resultados obtidos para o Observatório Astronômico (OA) da Universidade Federal de Alfenas, Brazil.

Keywords. Astrometry - Stars: variables

1. Introduction

Although they are a minority among all stars in the universe, variable stars constitute a very important area of stellar astrophysics (Kepler & Saraiva 2014). By analyzing the nature of the variability of these stars it is possible to obtain information about stellar properties such as mass, radius, luminosity, temperature, internal and external structure, composition and evolution (Lopes 2013).

An important source of information about variable stars is the catalog developed by a variable star research group at the Moscow State University in Russia, the General Catalog of Variable Stars (GCVS) (Samus et al. 2017). This catalog relies on a vast set of data regarding the variable stars mapped in the Milky Way and also neighboring galaxies.

In this work we present a strategy to identify the GCVS variable stars that can be monitored in na astronomical observatory, according to its location and instrumental configuration. The work is divided into 3 parts. In the first one will be presented the main concepts on variable stars. In the second the concepts about position astronomy, important for the understanding of the methodology developed. n the third part we will determine the variable stars that can be monitored in the UNIFAL-MG astronomical observatory. In the final considerations will be presented suggestions of teaching and research activities, at postgraduate level in teaching physics and astronomy about variable stars.

2. Variable Stars

Most stars have luminosity virtually unchanged in time. Occurs the slow variation of brightness due to the own process of stellar evolution, which entails in the change of stars deposition in the HR diagram. But there is a class of stars, the variable stars, whose luminosity varies in a short period of time.

The variable star concept applies only to the observable phase of the star throughout human existence. By measuring and recording the variability of the magnitude of the variable stars as a function of time, it allows the stellar light curve to be established. The behavior of this type of star can be studied by analyzing its light curve, making possible the determination of the period of variability of the star. The period is the amount of time it takes the star to pass through a complete cycle — from maximum magnitude to minimum magnitude — to return the maximum magnitude.

Variable stars are divided into two groups: intrinsic variables and extrinsic variables. The intrinsic variables are those in which the variability of its brightness stems from the star's own physical structure (contractions, expansions, eruptions and explosions in its outer layers). The extrinsic variables are those in which the variability of their brightness results from factors external to the stellar physical constitution (partial or total eclipses in binary or multiple systems, spots in the star's chromosphere).

3. Position Astronomy

The Sun in its movement through the ecliptic, apparent trajectory that the star travels throughout the year, presents different configurations in the sky. In the passage of the Sun by the vernal point (or Aries point), which occurs when the ecliptic intercepts the celestial equator, the star has a right ascension (α) equal to 0h (zero hours). The day of the year in which this event occurs is called the march equinox. The right ascension of a star is the angle measured on the celestial equator between the meridian of the vernal point and the meridian in which the star is found, varies between $0\text{h} \leq \alpha \leq 24\text{h}$. When a star has $\alpha = \pm\ 12\text{h}$ than the right ascension that the Sun is, that is, it is diametrically opposite to the Sun in the celestial sphere at that date, the star is in the best position for its observation.

Why use the Sun as a reference? Knows if approximately the day of the year in which the Sun has $\alpha = 0h$, so it is possible to determine the Julian date corresponding to that day. By means of the julianed equinox date of march it will be possible to find the julian day corresponding to the best date for the observation of each star. After being found the julian day it will be easy to define the julian date of each of the stars. Then, by means of some simple calculations, we will convert that date julian to gregorian date.

3.1. Determination of the best Julian day for observation

The following is the step-by-step guide for determining the best date of the year for stargazing. More detailed information on julian date conversion, position astronomy concepts can be found in Boczko (1984).

1. Determine the Julian date (JD) dated 03/20/2017:

$$\mathrm{JD} = \mathrm{int}(365,25 * \mathrm{Year} - T) + \mathrm{int}(30,6001 * (\mathrm{Month} + 1)) + \mathrm{Day} + 1720994,5 + \frac{\mathrm{Hour}}{24} \quad (1)$$

2. Days (D) passed from day 0 to 20/03 in the Julian calendar:

$$\mathrm{D} = \mathrm{JD} - \mathrm{JDO} \quad (2)$$

   The JD0 finds a value based on the date 0/1/Year at 12h (Bierrenbach 2017). The JD0 is obtained by the same equation used to calculate the JD, considering that it will only have changes regarding the value of the date and time.
3. Star diametrically opposed to the sun:

$$\alpha < 12\mathrm{h}, \mathrm{soon}\ \ \alpha_{\mathrm{Sun}} = \alpha - 12 \quad (3)$$

$$\alpha > 12\mathrm{h}, \mathrm{soon}\ \ \alpha_{\mathrm{Sun}} = \alpha + 12 \quad (4)$$

4. For the Sun to vary by 1h to α Sun:

$$\alpha * \mathrm{number\ of\ days} = 365,25/24\mathrm{h} \approx 15,219\mathrm{days/hour} \quad (5)$$

5. Julian day corresponding to the value of α Sun:

$$\alpha_{\mathrm{Sun}} * \mathrm{number\ of\ days} = \mathrm{X} \quad (6)$$

   We should point out that the above calculation is made from the date of the equinox in March, that is, by that date a certain amount of days will have passed. Thus, the result of equation 5 should be summed with the result found in equation 2.
6. Julian day:

$$\mathrm{Julian\ Day} = X + D \quad (7)$$

   A consequence of the result obtained by equation 6 is that this value can exceed the quantity of 365 days. If so, admit the following condition:
   If Julian day < 365 days: Julian day = Julian day;
   If Julian day > 365 days: Julian day = Julian day – 365.
7. Julian Date (JD) corresponding to the best day for stargazing:

$$\mathrm{JD} = \mathrm{JD0} + \mathrm{Julian\ Day} \quad (8)$$

8. The last step is the conversion of julian date to Gregorian date (day, month, year) for each of the variable stars. Detailed and detailed step-by-step explanations of how to do this conversion is found in reference (Bierrenbach 2017).

4. Variable Stars of the GCVS observable in the OA of UNIFAL-MG

Monitoring any celestial body requires that at least two conditions be allowed: location on planet Earth and instrumentation used. For the location of the Astronomical Observatory (OA) of the Federal University of Alfenas (latitude 21°25′45″ south of the equator and longitude 45°56′50″ West of the Greenwich meridian) the best candidates have declination in the range $-40° \leq \delta \leq 10°$.

The other criterion for the selection of stars concerns the potentiality of the instrument of observation. A relevant feature when it comes to a telescope is the size of your mirror or lens. The larger the aperture of the telescope, the greater the amount of light it can capture. The OA has as its main observation instrument a reflecting telescope with a 14"(fourteen-inch) mirror, a small telescope. Weak light stars, that is to say with an apparent magnitude higher than 10, are unfeasible and unlikely to be observed in the OA telescope. In this way, variable stars with a minimum apparent magnitude of less than 10 were selected.

5. Conclusions

A total of 1807 GCVS variable stars were possible to be observed in the OA of the Federal University of Alfenas. In this mapping appeared stars of different types of variability, with 70.6% of intrinsic nature, 26.1% have extrinsic variability and 3.3% without identification by GCVS. Of the total intrinsic variable stars, 49.09% correspond to long-period Mira and semi-regular variables. Among the stars of extrinsic variability the eclipsing binary systems of the Algol type appeared more frequently, corresponding to 8.23% of this group. The method to characterize the variable stars as described in this work seems to be a good proposal for the teaching of astronomical concepts, making possible that teaching and research activities at the undergraduate and graduate levels regarding the variable stars are performed.

References

Kepler, S. O., Saraiva, M.F.O. 2014, Astronomia e Astrofísica, (São Paulo: Editora Livraria da Física), pg. 282

Lopes, C. E. F. 2013, in Estudo sistemático de estrelas variáveis na era dos grandes surveys. UFRN: Tese de doutorado, pg. 1-2

Samus, N. N., Kazarovets E. V., Durlevich O. V., Kireeva N. N., & Pastukhova E. N. 2017, Astronomy Reports, 61, 80

Bierrenbach, G.L.N. 2017, Astronomia de Posição — notas de aula, versão 01/02/2017, IAG/USP. Disponível em `http://www.astro.iag.usp.br/~gastao/AstroPosicao/Curso2016.pdf`, acesso em 28/6/2017. pg. 12-13.

Boczko, R. 1984, Conceitos de astronomia, (São Paulo: Editora Edgard Blücher), pg. 44-45.