A study the period variation rate of V1292 Taurus Type RR Lyrae variable star

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Abstract. This research was aimed to study the period variation rate of V1292 Taurus type RR Lyrae variable star. The observational data was obtained on 0.5 meter Reflecting Telescope with CCD photometer camera in (Blue light, B) and (Visible light, V) bands at Regional Observatory for the Public, Nakhon Ratchasima province. The data have been analyzed to plot the light curves. From the (Observed-minus-Calculated, O-C) diagram analysis, we see that the period of this variable star is $0.5714981 \pm 0.0001563$ days and the period variation rate is increased of $4.8669436$ sec/year.

Introduction
Stars are born from the merger of gas particles and dust in space under gravity which pulls the particles to the center of mass when the temperature at the core of those particles increases to 10 megakelvins. When the core temperature rises to 15 megakelvins, it generates a thermonuclear reaction, fuses hydrogen nucleus as helium nucleus. Hence, the balance between gravity and the pressure of the particles causes a complete star. For the evolution of stars will follow the Hertzsprung-Russell diagram. For the evolution of most stars, when the star moves out of the main sequence, it changes its physical properties resulting in a change in luminosity. Astronomers call this star a variable star and categorize the variable stars according to the changes of physical properties of stars that result in the changes of luminosity into two categories: Extrinsic variable are variable stars that changes the outward appearance of the stars resulting in two types of divergence: Eclipsing binary and Rotating variables, Intrinsic variables are variable stars that change internal physical properties resulting in two types of divergences: Pulsating variables that caused by the periodic expansion and contraction of the surface layers of the stars and Eruptive or cataclysmic variables that caused by stellar eruptions. By astronomer, the four different types of pulsating variable stars are distinguished by their light curves: Cepheids, RR Lyrae, RV tauri, and Long-preiod variables. For Eruptive or cataclysmic variables stars, astronomers have divided these types of stars by the light curves into six types: Supernova, Nova, Recurrent novae, Dwarf nova, Symbiotic and R Coronae borealis.

The RR Lyrae is a variable star that changes its luminosity which classified as the very age old star with a low mass and low metal content. The average illumination in the absolute V magnitude is about 0.75 or 40 to 50 times brighter than the sun. The period of the star is about 1.5 to 24 hours that varies with the absolute brightness. Thus, astronomers use the RR Lyrae to calibrate the determination of the cluster distances. The RR Lyrae spectrum is in the range of A7-F5. The study of RR Lyrae-type stars has enabled astronomers to understand the chemical mechanism of age-old stars.[1] Based on period of the star, the RR Lyrae is now classified into three main types: RRe, RRa and RRb with the period of 0.3, 0.5 and 0.7 day respectively. The periodic expansion and contraction of RR Lyrae variable star is found in the basic mode and first overtone mode.[10] In 2006, Patrick Wils studied the search of
RR Lyrae variable stars in the Northern sky. Based on General catalogue of variable star (GCVS), the period analysis and light-curve shape of 3,000 stars were conducted and it was found that 785 RR Lyrae have been identified of which 188 are new discoveries. According to the study, when the period of RR Lyrae variable stars is considered, the periods in the RRab and RRc ranges up to 314. V1292 Taurus variable star is classified as one the variables stars in the RR Lyrae. According to a study in 1999, it was found that the period variation is 0.57148 days, considered as RRa variable star. Yet, there is no study of the period variation and the period variation rate at the present time in order to better understand the V1292 Taurus type RR Lyrae.

Methodology
To study the period variation rate of the V1292 Taurus type RR Lyrae variable stars, the data collecting lasted for 7 days. The image data was collected on 2nd, 3rd, 4th and 8th November 2015, 10th, 27th January 2016, and 6th February 2016 at the 7th Cycle Birthday Anniversary Commemoration Nakhon Ratchasima Observatory. The image data of V1292 Taurus type RR Lyrae variable stars was collected using reflecting telescope with 0.5 m in diameter that mounted in equatorial mount system along with an automatic star tracking system, connected with CCD photometer through blue light, B and visible light, V.

Observed image data was reduced (reduction image) due to the errors of instrument that include: Bias frames, Dark frames and Flat frames. Then, we measure the magnitude of the variable star by photometric technique using the Iris program.

Light curves of variable stars are plotted from the relationship between Heliocentric Julian Date (HJD) and apparent magnitude in order to analyze for the time that light is the most precious (Time of maximum). Then take the value of time of maximum to create a relationship graph between epoch and time of maximum to calculate the period variation at the current time and analyze the period variation rate from O-C Diagram.

Results
Based on the observed data of V1292 Taurus type RR Lyrae variable stars, 447 star images in the wavelength of blue light (Filter B) and 497 star images in visible light were obtained. To analyze the apparent magnitude, check star and reference star is needed in order to approve the metric measurement position of the apparent magnitude of variable stars to be studies in the image data. The position of the studied star, check star and reference star in the observed images and the position of the star in the images is shown in Figure 1.

| Order | Name of stars | R.A. | DEC. | Filter B | Filter V |
|-------|---------------|------|------|----------|----------|
| 1     | V1292 Taurus RR Lyrae | 03 57 07.77 | +28 50 26.6 | 14.48 | 13.69 |
| 2     | TYC 1825-1413-1 | 04 00 37.994 | +28 56 07.56 | 12.98 | 12.02 |
| 3     | TYC 1825-1897-1 | 04 00 08.567 | +28 47 54.26 | 12.50 | 12.11 |
| 4     | TYC 1825-1991-1 | 04 00 55.452 | +29 03 00.10 | 13.27 | 11.70 |
| 5     | TYC 1825-1491-1 | 03 59 20.065 | +28 57 41.06 | 13.20 | 12.51 |
Then the observational data were analyzed by photometric method. Take measured data to create graphs from the relationship between HJD and Apparent magnitude of the wavelength of blue light (B) and visible light (V). Light chart are presented in Figure 2 and 3.

From the light chart in Figure 2, 3, the maximum and minimum of magnitudes can be analyzed by creating the light chart of observation data as presented in Table 2.

| Wavelength range | Minimum of magnitudes | Maximum of magnitudes |
|------------------|-----------------------|-----------------------|
| Visible light    | 13.95                 | 12.93                 |
| Blue light       | 14.63                 | 13.43                 |

Considering the time when the light is the most precious (Time of maximum) of this study and the earlier researches in order to calculate the epoch by using Linear ephemeris of V1292 Taurus RR Lyrae variable stars that studied by [9] that are Equation 1 and Equation 2.

\[
\text{Time of maximum} = 2451531.68 + 0.57148E \\
\]  

(1)
Time of maximum = 2451531.75 + 0.571498E

The value of V1292 Taurus RR Lyrae variable stars is 0.571498E ± 0.000156349 days. Then take the period variation in the current time to calculate the period variation rate from past to present from by using O-C Diagram.

Table 3. Results of O-C calculation of V1292 Taurus RR Lyrae variable stars.

| Time of Maximum | Period  | Observed | Calculated according | Epoch | O-C Diagram | Research works |
|-----------------|---------|----------|----------------------|-------|-------------|----------------|
| 2451531.680     | 0.5714800 | 2451531.68 | 2451531.68 | 0     | 0           | Patrick Wils 1999AD |
| 2453708.129     | 0.5712187 | 2453706.88 | 2453707.87 | 3808  | -0.9950304  | A.J. Drake 2005AD |
| 2457331.271     | 0.571498  | 2457331.24 | 2457331.05 | 10148 | 0.1836788   | P. Prachumlek 2016AD |

Calculation of period variation rate of variable star from the relationship between Epoch and O-C as presented in Figure 5.

From the diagram of Epoch and O-C of V1292 Taurus RR Lyrae variable stars, numerical values were analyzed with second-order polynomial fitting and it could be analyzed that rate of expansion and contraction of V1292 Taurus RR Lyrae variable star was shown the increasing in the period variation at $8.8138802 \times 10^{-8}$ day/cycle or $4.8669437 \text{sec/year}$ from the relationship between period variation and density of expansion and contraction star $P = 1/\sqrt{\rho}$. It can be seen that the density of V1292 Taurus RR Lyrae variable stars was decreased since the period variation was increased. It can be analyzed that V1292 Taurus RR Lyrae was expanding.

Conclusion

From the study of V1292 Taurus RR Lyrae variable star at celestial sphere position RA 04 00 13.53, DEC +28 58 46.9, the data collecting lasted for 7 days, made photometry by the iris program – Shortcut and the collected data in epoch session 10148 which corresponds to the time that the light is
the most precious and equivalent to Heliocentric Julian Date equal 2457331.27140. When the values of Julian Day Solar Center was used to create the diagram between Epoch and Time of maximum with Liner ephemeris, the new quotation of this study was HJD = 2451531.7509418 + 0.5714981E. It was found that the period variation at the present time was 0.5714981 ± 0.0001563 days. From the period variation, the V1292 Taurus RR Lyrae variable star is in the RRa group. Then analyze the O-C diagram, It was found that the period variation rate of V1292 Taurus RR Lyrae variable was increased to 4.8669436 second per year.

Suggestions

This research was aimed to study the period variation and period variation rate. However, for those who interested in this variable star can study further regarding distance, radius, and age of variable stars in order to get deeper understanding about V1292 Taurus RR Lyrae variable star.

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