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GEOS RR Lyrae Database and Survey: A Professional-Amateur Project

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GEOS, a European professional-amateur association, has collected in a database available times of maximum of RR Lyrae stars. We scanned the publications back to more than one century for this purpose. Recent observations are regularly added to the database. Measurements from amateur astronomer groups (GEOS, BAV, AAVSO) and from the robotic telescopes *TAROT* are used. To date, the database contains about 96 000 maximum times from 4 000 RR Lyrae stars. This database is particularly useful to study period variations of RR Lyrae stars including phenomena like the Blazhko effect and light travel time effects in binaries.

1 GEOS RR Lyrae Database

The database interface on the web¹ is a tool for the study of RR Lyrae stars. This web interface allows us to follow period variations since a star's discovery, sometimes more than 100 years ago. The aim of the database is to maintain an up-to-date list of observed maxima of RR Lyrae stars.

The original idea of the database in 1999 was to update the data published in the book "RR Lyr Stars", written by Vladimir P. Tsesevich, from the 1960s (Tsesevich, 1969) and make them available on the web. First, we collected published historical times of maximum light. We regularly surveyed publications, both professional journals and amateur papers. In September 2017, the database contained 96 940 maxima on 3 984 stars. The web interface of the database gives the list of maxima, O–C curves, and basic data of the stars. The database is made of 6 tables from which data are extracted to build the web pages:

- A catalog which contains the list of known RR Lyrae stars (with coordinates, variation type, and magnitudes)
- An alias name table to cross-correlate the various names of a given star.
- Table of elements giving initial epochs of maximum brightness and periods.
- The list of observed maxima.
- Literature references.
- Comments.

¹<http://rr-lyr.irap.omp.eu/dbrr/>

All the tables are indexed to the star catalog table (first table of the list above). This internal catalog is updated by frequent access to catalogs such as General Catalog of Variable Stars (GCVS) and AAVSO International Variable Star Index (VSX). The access to the data of a given star is made either by its name or its coordinates.

2 GEOS RR Lyrae Survey

In parallel to the database, the GEOS RR Lyrae Survey (GRRS) aims to add significantly more maximum timings of the brightest RR Lyrae stars by essentially using robotic telescopes. GRRS also include the study of fainter understudied stars which are not followed by robotic telescopes in order to refine their period and find new stars which exhibit Blazhko phenomena.

The expected long life of the survey should allow us to follow the evolution of the Blazhko effect and other long term variations of RR Lyrae stars. The survey started in 2004. It is composed of 3 parts:

- For Robots: routine observations of maxima of bright RRab stars (magnitude range 9 – 13). Aim: To survey light curve variations at large time scales.
- For Human observers: study of fainter understudied stars (magnitude range $\sim 13 - 15$). Aim: To refine or find a period and possible new Blazhko phenomena.
- For Human observers: followup of RR Lyr with small dedicated instruments.

2.1 Routine observations of maximums of bright RRab

The RR Lyrae star survey is one of the additional programs of the robotic telescopes *TAROT* (25 cm diameter mirror) (Klotz et al., 2009), which are dedicated to the follow up of gamma ray bursts and observations of Earth's artificial satellites. The observation of six RR Lyrae is scheduled on each telescope every night (i.e., these 6 measurement series are scheduled to observe predicted maxima according to known element):

- Calern observatory, France: since 2004, 9 200 times of maximum were determined on 300 stars
- La Silla observatory, Chile: since 2006, 7 800 times of maximum were determined on 360 stars

2.2 Study of neglected stars

The observation of the faintest RR Lyrae is neglected. These neglected stars are typically those with a magnitude at light minimum fainter than about 13. Often the pulsation period and subtype are not accurately known, and we do not know if there is a Blazhko effect.

These observations are done in the GRRS framework by observers using 20 to 60 cm telescopes. The observing plan is to get complete folded light curves in a short time (about one week), and do it again several weeks or months later. Over 10 years, about 25 amateur astronomers have contributed to the program. Approximately 100 RR Lyrae stars were observed in this program. Some of them show a previously unknown Blazhko effect.

2.3 Followup of the Blazhko effect of RR Lyr itself

RR Lyr is a well known bright star of magnitude 7 – 8 (period 0.51 days, Blazhko effect period ~ 40 days). However, RR Lyr has a variable Blazhko effect with a time scale of several years, which has not been studied since Preston et al. (1965). Studying variable Blazhko effect requires continuous observation during years. This is why we designed small dedicated instruments to follow RR Lyr (Le Borgne et al., 2014). They are made of a commercial “goto” mount (Skywatcher HEQ5) and a CCD camera attached to a telelens of 5 cm diameter and 135 mm focal. Image acquisition is automated as well as real time basic data reduction, from dark removal to astrometric and photometric calibrations. Between 2008 and 2017 we obtained 1100 series of observations from which resulted the determination of 400 times of maximum. We observed the decrease of the amplitude of the Blazhko effect (Le Borgne et al., 2014) and eventually its disappearance in 2014 as observed in 1963 by Preston et al. (1965). The Blazhko effect of RR Lyr restarted in 2015, but, since then, its amplitude remains small (see Poretti et al., this conference).

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