

# Analysis of the Blazhko Effect for Field RR Lyrae Stars using LINEAR and ZTF Light Curves

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## Abstract

We analyzed the incidence and properties of stars that show evidence for amplitude, period, and phase modulation (the so-called Blazhko Effect) in a sample of  $\sim 2,000$  field RR Lyrae stars with LINEAR and ZTF light curve data. A preliminary subsample of about  $\sim 800$  stars was selected using various light curve statistics, and then  $\sim 200$  stars were confirmed visually as displaying the Blazhko effect. Although there are close to 8,000 Blazhko stars discovered in the Galactic bulge and LMC/SMC by the OGLE-III survey, there are only about 200 stars in total reported in all the studies of field RR Lyrae stars to date and thus the sample presented here doubles the number of such stars. We found that...

*Subject headings:* Variable stars — RR Lyrae stars – Blazhko Effect

## 1. Introduction

RR Lyrae stars are pulsating variable stars with periods in the range 3–30 hours and large amplitudes that increase towards blue optical bands (e.g., in the SDSS  $g$  band from 0.2 mag to 1.5 mag; ?). In addition to being interesting astrophysical objects that provide constraints for the stellar pulsation theory and internal structure calculations, RR Lyrae are an important population for studying Galactic structure because they are calibrateable standard candles and sufficiently bright to be detected at large distances; thus they represent an excellent tracer of low-metallicity outer halo population. For comprehensive reviews of RR Lyrae stars, we refer the reader to ? and ?.

RR Lyrae stars often exhibit amplitude, period, and phase modulation, or the so-called Blazhko effect (hereafter, “Blazhko stars”). For examples of well-sampled observed light curves showing the Blazhko effect, see, e.g., Kepler data shown in Figures 1 and 2 from ?.

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The reported incidence rates for the Blazhko effect range from 5% (?) to 60% (?). For a relatively small sample of 151 stars with Kepler data, a claim has been made that essentially every RR Lyrae star exhibits modulated light curve (?). The difference in Blazhko incidence rates for the two largest samples, obtained by the OGLE-III survey for the Large Magellanic Cloud (LMC, 20% out of 17,693 stars; ?) and the Galactic bulge (30% out of 11,756 stars; ?), indicate possible variation of the Blazhko incidence rate with underlying stellar population properties.

The Blazhko effect has been known for long time (?), but its detailed observational properties and theoretical explanation of its causes remain elusive ?. Quoting ?: “As of this writing, we do not have a clue why many RR Lyrae stars vary their amplitudes that leads in some cases nearly ceasing pulsation in the low-amplitude states. [...] with no physically justified and testable idea/model we miss some basic ingredient not just in the pulsation models but most likely in the evolutionary models, too.”. References to various proposed models for the mysterious Blazhko effect and main reasons why they fail to explain observations are summarized in ?.

A part of the reason for incomplete observational description of the Blazhko effect is difficulties in discovering a large number of Blazhko stars due to temporal baselines that are too short and insufficient number of observations per object (??). With the advent of modern sky surveys, a number of studies reported large increases in the number of known Blazhko stars, starting with a sample of about 700 Blazhko stars discovered by the MACHO survey towards LMC (?) and about 500 Blazhko stars discovered by the OGLE-II survey towards the Galactic bulge (?). Most recently, about 4,000 Blazhko stars were discovered in the Large and Small Magellanic Clouds (??), and an additional  $\sim 3,500$  stars were discovered in the Galactic bulge (?), both by the OGLE-III survey. Nevertheless, discovering the Blazhko effect in field RR Lyrae stars that are spread over the entire sky remains a much harder problem: only about 200 Blazhko stars in total from all the studies of field RR Lyrae stars have been reported so far (see Table 1 in ?).

Here we report the results of a search for the Blazhko effect in a sample of  $\sim 2,000$  field RR Lyrae stars with LINEAR and ZTF light curve data. A preliminary subsample of about  $\sim 800$  stars was selected using various light curve statistics, and then  $\sim 200$  stars were confirmed visually as displaying the Blazhko effect. This new sample doubles the number of known field RR Lyrae stars that exhibit the Blazhko effect. In §?? we describe our datasets and analysis methodology, and in §?? we present our analysis results. Our main results are summarized and discussed in §??.