

GK Car and GZ Nor: Two low-luminous, depleted RV Tauri stars

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Abstract. RV Tauri stars are luminous population II Cepheids which show a characteristic light curve of alternating deep and shallow minima. There are 126 RV Tauri variables in our Galaxy. Using WISE [3.4]-[4.6], [12]-[22] diagram we show that Galactic RV Tauri stars show three main types of IR properties in their SEDs; disc-type, non-IR and uncertain, which does not show a clear characteristic in the SED. We also show that there is a strong correlation between disc-type SED and binarity (Gezer *et al.* 2015). RV Tauri stars were linked to post AGB stars in early studies (Jura 1986), however, recent studies show that their evolutionary nature is more complex than previously thought (Kamath & Van Winckel 2014, and Manick *et al.* 2018). In this study, we intentionally selected two RV Tauri stars, GK Car (disc-type) and GZ Nor (uncertain), with different IR characteristics to compare their chemical and photometric properties.

Keywords. stars: AGB and post-AGB, stars: abundances, stars: variables: Cepheids.

1. Luminosity and Distance Estimates

Using ASAS photometry, the accurate pulsation periods have been obtained via period analysis. The obtained periods are used to derive luminosities and distances. The total extinction $E(B-V)$ values are obtained from the SED fitting. For GK Car we obtained a total reddening of $E(B-V)=0.41\pm 0.1$, while for GZ Nor $E(B-V)=0.45\pm 0.1$ was found. We computed luminosities using three different methods. First, we derived the luminosities using the Period Luminosity Colour (PLC) relation given by Manick *et al.* (2017). Second, we obtained the bolometric luminosities, L_{SED} , for each star using the integrated flux below the dereddened SED model and the obtained distances. We also calculated distance and luminosity using GAIA parallax, however, GAIA parallax is available for only one of our stars (GK Car). Obtained distances and luminosities are given in Table 1.

2. Chemical Analysis

High-resolution, high signal-to-noise spectra for GK Car and GZ Nor were obtained with the Ultraviolet and Visual Echelle Spectrograph mounted on the 8m UT2 Kueyen Telescope of the VLT array at the Paranal Observatory of ESO in Chile. The abundances were calculated on the basis of LTE model atmospheres of Kurucz (Castelli & Kurucz 2003) and MARCS (Gustafsson *et al.* 2008) and the LTE chemical composition determination routine MOOG (version July 2009) (Snedden 1973). For GK Car we obtained $T_{\text{eff}} = 5500 \pm 125$ K, $\log g = 1.0 \pm 0.25$ dex, microturbulent velocity $\xi_t = 5.5 \pm 0.5$ km/s, and $[\text{Fe}/\text{H}] = -1.32 \pm 0.1$. For GZ Nor the atmospheric parameters are as follow: $T_{\text{eff}} = 4875 \pm 125$ K, $\log g = 0.50 \pm 0.25$ dex, $\xi_t = 4.0 \pm 0.5$ km/s, $[\text{Fe}/\text{H}] = -2.05 \pm 0.1$. With an

Table 1. The fundamental pulsation period (P_0) is given in Col.2. Calculated distances and luminosities using PLC relation are shown in Cols.3 and 4, respectively. Only for GK Car, the distance and luminosity is calculated using parallax and they are given in the last two columns.

Star	P_0 (days)	Distance (kpc)	Luminosity (PLC) (L_\odot)	Luminosity (SED) (L_\odot)	Distance (plx) (kpc)	Luminosity (plx) (L_\odot)
GK Car	27.6, 55.2	4.55 ± 0.59	1762 ± 450	1626 ± 264	4.30 ± 0.57	1455 ± 390
GZ Nor	36.2, 72.4	8.42 ± 1.0	1560 ± 340	1425 ± 234	–	–

$[\text{Fe}/\text{H}] = -1.3$ and a $[\text{Zn}/\text{Ti}] = +1.2$ for GK Car and a $[\text{Fe}/\text{H}] = -2.0$ and a $[\text{Zn}/\text{Ti}] = +0.8$ for GZ Nor, both stars show depletion of refractory elements in their photospheres. In a depleted photosphere, refractory elements, which have high dust condensation temperature, are underabundant, while volatiles, which have low condensation temperature, are more abundant (Van Winckel 2003). Waters, Trams, & Waelkens (1992) proposed that the most likely circumstance for the process to occur is the dust trapping in a circumstellar disc. All depleted atmospheres have been detected in binary post-AGB objects so far (Van Winckel, Waelkens, & Waters 1995, Gezer *et al.* 2015). The most characteristic chemical signatures of depleted photospheres are high $[\text{Zn}/\text{Fe}]$, $[\text{Zn}/\text{Ti}]$ and $[\text{S}/\text{Ti}]$ ratios. GK Car and GZ Nor both show a depletion characteristic in their atmosphere. This would imply that they are likely binary objects.

3. Conclusions

In this study, we show that GZ Nor is RV Tauri variable with a disc. GK Car and GZ Nor are both depleted RV Tauri stars with disc hence we conclude that they are likely binary objects. All RV Tauri stars with the disc-type SED are likely binaries and they probably follow different evolutionary channels depending on the initial mass of their primaries. The luminosity of the tip of the Red Giant Branch (RGB-tip) for $1 M_\odot$ is $2615 L_\odot$ (Bertelli *et al.* 2008). The obtained luminosities for GK Car ($1762 L_\odot$) and GZ Nor ($1560 L_\odot$) are lower than the predicted RGB-tip luminosity of a $1 M_\odot$ star. Thus, they very likely evolve off the RGB due to a strong binary interaction process, which occurs already on the RGB.

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