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Evolutionary status of selected post-AGB stars based on Gaia DR3

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ABSTRACT

The evolutionary status of 24 post-AGB stars is presented based on Gaia DR3 data. All 24 stars have parallaxes accurate to better than 3σ and have RUWE values < 1.4. Based on the Gaia DR3 distances the absolute luminosities are derived. For 14 of the stars, the luminosities confirm their post-AGB evolutionary stage. However, V1027 Cyg, which was previously classified as a post-AGB star, is found to have a higher luminosity than would be expected if it was truly a post-AGB star; thus it may be an evolved, massive, pulsating semi-regular variable star of type G7Ia. For 9 of the stars, the luminosities are lower than 1000 $L_\odot$, indicating that some are post-HB stars and some are post-RGB stars.

INTRODUCTION

Post-asymptotic giant branch (AGB) supergiants are stars that have recently evolved off the AGB but have not reached high enough temperatures to photoionize their circumstellar dust envelopes (Parthasarathy & Pottasch 1986, Hrivnak et al. 1989). The evolutionary stage of post-AGB supergiants is short-lived depending on the core mass (Schoenberner 1983). During the transition from the tip of the AGB to the young planetary nebula phase, these stars have spectral types that evolve from M to OB (Parthasarathy 1993a), and they mimic the spectra of supergiants because after the termination of the AGB phase of evolution they have a white-dwarf C–O core with a very thin extended envelope. During the past 36 years, analysis of IRAS data, and accompanying multi-wavelength studies, has resulted in the identification of a few hundred post-AGB stars (Vickers et al. 15). Until recently their distances were not known therefore it was not possible to place them on the post-AGB evolutionary tracks. With the advent of Gaia satellite now we have accurate parallaxes for large number of post-AGB stars. It is now possible to derive their absolute luminosities and to compare them with the results of the pst-AGB stellar evolutionary models (Parthasarathy et al. 2020, Kamath et al. 2022, Parthasarathy 2022, Aoki et al. 2022).

In this paper we present an analysis of Gaia DR3 data (Gaia Collaboration 2022) of 24 post-AGB stars. These stars are selected because they have accurate Gaia DR3 parallaxes, RUWE values less than 1.4 (Stassun & Torres 2021) and they are not known to be close binaries.

SELECTION OF STARS AND THEIR GAIA DR3 DATA

We selected from the list of post-AGB stars given in Vickers et al. (2015). Several stars have Gaia DR3 parallaxes comparable or less than their errors in parallaxes and several stars have RUWE values > 1.4. We have not considered these stars. The selection criteria that we adopted is that they need to have accurate Gaia DR3 parallaxes ($> 3\sigma$), they need to have RUWE values less than 1.4, they are single stars (not known to be binaries) and their Gaia data has not been analyzed so far. With this criteria we selected 24 stars.

RESULTS

The Gaia DR3 parallaxes (distances) of the selected sample of stars were used to derive their absolute luminosities. Their V, $B - V$ and spectral types were taken from SIMBAD. In order to derive their absolute luminosities we need to take into account the interstellar and circumstellar reddening. Many of our stars are IRAS sources and have circumstellar dust shells.

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Interstellar and circumstellar reddening

Several stars are located at high galactic latitudes therefore their interstellar reddening values are relatively low. We took a simple approach to estimate interstellar plus circumstellar reddening. The observed $B-V$ is affected by both interstellar plus circumstellar reddening. All of our stars have MK spectral types. We used the calibration between MK spectral types and corresponding intrinsic $(B-V)_0$ values given in Allen's Astrophysical Quantities 4th edition (Cox 2000) and Flower (1996). The difference between the observed $(B-V)$ and $(B-V)_0$ obtained from the spectral types yields $E(B-V)$.

Using the following equation we derived the absolute visual magnitudes of the stars:

$$M_V = V + 5 - 5\log(d) - 3.3E(B-V).$$

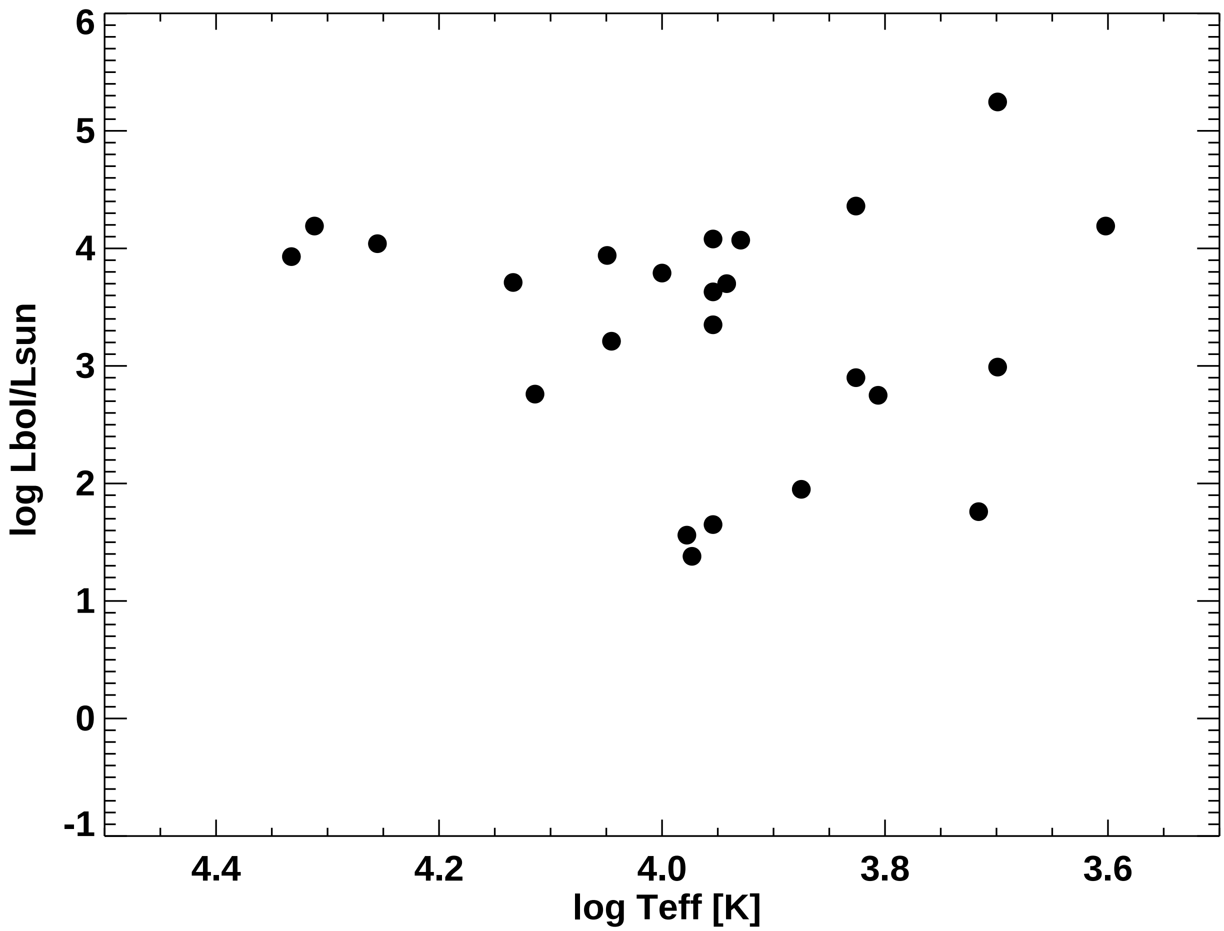

Figure 1. HR Diagram positions of the sample stars.

Luminosities

To calculate the absolute bolometric magnitudes $M_{\rm bol}$ we used the bolometric corrections (BC) given in Allen's Astrophysical Quantities (4th edition) (Cox 2000). For several stars in this sample $T_{\rm eff}$ values are available in the literature (based on the analysis of their spectra). The references for $T_{\rm eff}$ values are given in the Section 3.4.1 notes. We have also used spectral types, $(B-V)_0$ and $T_{\rm eff}$ calibration given in Allen's Astrophysical Quantities (4th edition) (Cox 2000). $T_{\rm eff}$ values are not used in deriving the absolute luminosities. $T_{\rm eff}$ values are used only to examine the location of the stars in the H-R diagram (Figure 1).

Uncertainties

The errors in $E(B-V)$ are of the order of ±0.05 to ±0.10. The errors in derived M_V values are on the average less than 0.1. The errors in derived absolute luminosities $\log(L/L_\odot)$ of the order 0.10 dex. The errors in $T_{\rm eff}$ values are of the order of 500 K.

Classifications

We group the sample stars into several categories according to their positions in the Hertzsprung-Russell diagram and other considerations, where available, as discussed below.

Post-AGB stars

Includes the following: IRAS 01005+7910, IRAS 05040+4820, IRAS 10456−5712, IRAS 11353−6037, IRAS 11387−6113, IRAS 11531−6111, IRAS 14072−5446, IRAS 14488−5405, IRAS 16206−5956, IRAS 17311−4924, IRAS 20160+2734, and IRAS 20462+3416.

Post-AGB binaries

Includes the following: IRAS 11385−5517 and HD 105262.

Low-luminosity stars (post-RGB and post-HB)

Includes the following: LB 3193, IRAS 02528+4350, RV Col, IRAS 05381+1012, IRAS 13110−5425, IRAS 19410+3733, IRAS 20490+5934, IRAS 20572+4919, IRAS 21289+5815

High luminosity stars

Includes the following: IRAS 20004+2955.

COMMENTS ON V1027 CYG

V1027 Cyg (IRAS 20004+2955, HD 333385) is in the galactic plane. It is a semiregular variable star of spectral type G7Ia. Arkhipova et al. (2016) studied the photometric and spectral variability. The luminosity derived from Gaia DR3 data indicates that it is not a post-AGB star. It is most likely a massive star.

CONCLUSIONS

Based on the Gaia DR3 parallaxes of 24 selected post-AGB stars we derived their absolute luminosities. We find 14 of them have luminosities that confirm their post-AGB status. HD 101584 which was originally classified as a post-AGB star (Parthasarathy & Pottasch 1986); it is indeed a post-AGB star and not a a post-RGB star. LS II +34 26, SAO 40039, SAO 243756 and Hen 1428 are also confirmed to be hot post-AGB stars from this study.

Nine of the stars have luminosities $\log(L/L_\odot)$ much less than 3.5. LB 3193 which was classified as a high galactic latitude, galactic halo metal-poor hot post-AGB star is found to be only 575 $L_\odot$. It may be a post-HB star or a AGB-manque star. Some of the less luminous stars may be post-HB stars and some may be post-RGB stars. Some may be misclassified as post-AGB stars.

Finally, V1027 Cyg is found to have much higher luminosity than that of a typical post-AGB star. V1027 Cyg seems to be a massive, very luminous semiregular variable G7Ia supergiant.

REFERENCES

Aoki,W., Matsuni, T., Parthasarathy,M., 2022, PASJ (in press)
Arkhipova, V.P., et al., 2016, AstL 42, 756
Cox,A.N., 2000, Allen's Astrophysical Quantities (4th edition)
Flower,P.J., 1996, ApJ 469, 355
Gaia Collaboration, Vallenari, A., Brown, A. G. A., et al. 2022, arXiv:2208.00211
Hrivnak, B.J., et al. 1989, ApJ 346, 265
Kamath,D., et al., 2022, ApJ, 927, L13
Parthasarathy,M., 1993a, ApJ 414, L109
Parthasarathy,M., 2022, RNAAS 6, 33
Parthasarathy,M., Pottasch, S.R., 1986, A&A 154, L16

Parthasarathy,M., Muthumariappan,C., Muneer,S., 2020, Ap&SS 365, 127
Parthasarathy,Vijapurkar,J., Drilling, J.S., 2000, A&AS 145, 269
Schoenberner,D., 1983, ApJ 272, 708
Stassun,K.G., & Torres, G., 2021, ApJ 907, L33
Vickers, S.B., et al., 2015, MNRAS 447, 1673