BD+14°3061: A Luminous Yellow Post-AGB Star in the Galactic Halo

Howard E. Bond1,2,3 ©
1 Department of Astronomy & Astrophysics, Pennsylvania State University, University Park, PA 16802, USA
2 Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218, USA
Received 2020 September 8; revised 2020 October 12; accepted 2020 October 13; published 2020 November 19

Abstract

I report the discovery that the ninth-mag Galactic-halo star BD+14°3061 is a member of the rare class of luminous metal-poor “yellow post-AGB” stars. Its Gaia DR2 parallax implies an absolute magnitude of $M_V = -3.44 \pm 0.27$, and it is a very high-velocity star moving in a retrograde Galactic orbit. BD+14°3061 is a field analog of the half-dozen yellow PAGB stars known in Galactic globular clusters, which have closely similar absolute magnitudes. These objects are the visually brightest members of old stellar populations; their apparently narrow luminosity function makes them potentially useful as Population II standard candles. The spectral-energy distribution of BD+14°3061 out to 22 $\mu$m shows no evidence for circumstellar dust. The star is a low-amplitude semiregular pulsating variable, with typical periods of 30–32 days. A radial-velocity study suggests that it is a spectroscopic binary with a period of 429.6 days, making it similar to known binary yellow PAGB stars such as HD 46703 and BD+39°4926.

Unified Astronomy Thesaurus concepts: Post-asymptotic giant branch stars (2121); Evolved stars (481); Globular star clusters (656); Spectroscopic binary stars (1557); Semi-regular variable stars (1444)

1. Yellow Post-AGB Stars

The visually brightest objects in old populations are post-asymptotic-giant-branch (PAGB) stars, evolving at nearly constant luminosity to higher temperatures after leaving the AGB tip. As they pass through spectral types early G, F, and late A, where the bolometric correction is smallest, these “yellow PAGB stars” reach their brightest visual luminosities.

I have argued (Bond 1997a, 1997b) that yellow PAGB stars in early-type galaxies and halos of spirals are potentially excellent “Population II” standard candles for measuring extragalactic distances, because they are expected to have a very narrow luminosity function. Moreover, they are easy to detect because they have uniquely large Balmer discontinuities, arising from their very low surface gravities. A group of colleagues at Pennsylvania State University is undertaking a detailed study of these objects as standard candles, to be reported in a forthcoming series of papers.

To calibrate the photometric zeropoint, we primarily use yellow PAGB stars in Galactic globular clusters (GCs) with well-established distances. However, because of their short evolutionary timescales, these stars are extremely rare. Only about a half-dozen are known in the Galactic GC system (e.g., Bond et al. 2016, hereafter B16, and references therein; H. E. Bond et al. 2020 in preparation).

A few bright field analogs of these Population II1 yellow PAGB stars are known. Two prototypes are HD 46703 and BD+39°4926 (see B16 and references therein). The field stars are also potential contributors to the zeropoint determination, in cases where they are near enough for measurements of their trigonometric parallaxes with high relative precision.

1 Visiting Astronomer, Cerro Tololo Inter-American Observatory, National Optical Astronomy Observatory, operated by the Association of Universities for Research in Astronomy under a cooperative agreement with the National Science Foundation.

2 I am using the term “Population II” to mean objects that appear to belong to an old stellar population, based on kinematics and/or a spatial location in the Galactic halo (or of course in a globular cluster). A low iron content is not, by itself, enough to place a PAGB star in an old population, because of the photospheric depletion processes described below.

In this paper I report a bright yellow PAGB star in the field of the Galactic halo. My discovery and initial observations were actually made many years ago, but never published.5 As noted above, we are now studying this class of objects in detail, so it is appropriate to publish my discovery now. I will present data I have accumulated on the star, along with photometric data from all-sky surveys and precise astrometry from the Gaia mission.

2. BD+14°3061: A New Yellow PAGB Star

In the 1970s I carried out a survey for metal-deficient stars in the general field, using objective-prism plates obtained with the Curtis Schmidt telescope at Cerro Tololo Inter-American Observatory (CTIO). I followed up by obtaining photometry of the candidate stars in the Strömgren uvby system. I presented details of the objective-prism survey, a list of extremely metal-poor red giants that were discovered, and the uvby photometry, in an Astrophysical Journal Supplement Series paper (Bond 1980, hereafter B80).

In the course of examining a Curtis Schmidt plate I had obtained in 1977, I classified the previously unstudied ninth-mag star BD+14°3061 (hereafter shortened to BD+14) as having an extremely weak-lined F-type spectrum. I was not able to obtain Strömgren photometry until 1981. That measurement revealed that BD+14 is a new member of the rare class of extremely low-gravity yellow PAGB stars. Table 1 presents basic data on the star, and results from my observations. The astrometric measurements are from Gaia Data Release 2 (DR2; Gaia Collaboration et al. 2018).6

3. Strömgren Photometry

I obtained photoelectric uvby photometry of BD+14 on 1981 April 11, using the 0.9 m telescope at CTIO. I reduced the data

5 I did mention the discovery at a conference (Bond 1991), and on this basis the star was included in a catalog of Population II A-F supergiants compiled by Barkevicius (1992).

6 http://vizier.cfa.harvard.edu/viz-bin/VizieR-3?-source=I/345/gaia2
to the standard Strömgren system as described in B80, and they are presented in rows 6 through 9 in Table 1. The two panels in Figure 1 plot the Strömgren $c_1$ and $m_1$ indices versus $b - y$ color for BD+14. Also plotted for comparison are the prototype stars HD 46703 (from Luck & Bond 1984, hereafter LB84; the star is a low-amplitude variable and the mean of their measurements is plotted) and BD+39°4926 (Philip & Philip 1973). I corrected the photometry for all three stars for interstellar reddening, using the Stilism online tool\(^7\) (Capitanio et al. 2017), which estimates reddening, $E(B - V)$, at any given Galactic position and distance: $E(B - V) = 0.053 \pm 0.072, \text{and} \ 0.112 \text{for } BD+14, \text{HD } 46703, \text{and} \ BD+39^\circ4926$, respectively. I used the Crawford (1975) relations between reddening in the Strömgren and BV systems to make the reddening corrections.

The top panel in Figure 1 plots the gravity-sensitive $c_1$ index versus the temperature index $b - y$. All three stars have very high values of $c_1$, indicating extremely large Balmer discontinuities and low surface gravities. For an approximate calibration, I have overlaid the grid of theoretical colors from Relyea & Kurucz (1978, hereafter PK78), using a metallicity of $\log \text{[Fe/H]} = -2$. The lowest gravity in the RK78 tables at this metallicity is $\log g = 2$, so I linearly extrapolated their values to $\log g = 1.5$ and 1. The figure shows that BD+14 has an extremely low gravity, below $\log g = 1$, but the actual value is uncertain because of the extrapolation. The colors of BD+14 are nearly identical to those of HD 46703, for which LB84 used high-resolution spectra to determine $T_{\text{eff}} = 6000 \text{ K}$ and $\log g = 0.4$; subsequently (Hrivnak et al. 2008, hereafter H08), found 6250 K and 1.0 from an independent analysis. These values are in good accord with the position of HD 46703 in the top panel of Figure 1. BD+14 thus likely has very similar atmospheric parameters. For BD+39°4926, a high-dispersion analysis by Rao et al. (2012) gave ($T_{\text{eff}}, \log g$) = (7750 K, 1.0), in fairly reasonable agreement with Figure 1.

The bottom panel in Figure 1 plots the metal index $m_1$ versus $b - y$ for BD+14 and the two prototype stars. All three stars have low $m_1$ values, indicative of very weak metallic lines. In this panel I plot a grid of theoretical colors from RK78 for metal contents of $\text{[Fe/H]} = 0, -1, \text{and} -2$. These colors are for $\log g = 2$, the lowest gravity in the RK78 tables, so they are only a rough approximation for these very low-gravity stars. Nevertheless, it is clear that all three stars have very low metal contents. BD+14 is again nearly identical with HD 46703. LB84 found [Fe/H] $= -1.6$ for this star. For BD+39°4926, the Rao et al. study gave [Fe/H] $= -2.37$.

The photospheres of HD 46703, BD+39°4926, and several other PAGB stars show depletions of refractory chemical elements with high condensation temperatures (e.g., H08; Oomen et al. 2018, hereafter O18; Oomen et al. 2019; and references therein). This indicates that the refractory elements have been selectively removed from the gas through condensation onto grains in a cool region, with the gas then having been reaccreted onto the photosphere.\(^8\) A high-dispersion abundance analysis of BD+14 would be of considerable interest, to investigate whether it shows a similar effect.

---

\(^{7}\) https://stilism.obspm.fr/

\(^{8}\) To my knowledge, I was the first to suggest this explanation for the photospheric depletions: Bond (1991).

---

**Table 1**

| Parameter                        | Value       | Source |
|----------------------------------|-------------|--------|
| R.A. (J2000)                     | 16:29:48.591| (1)    |
| Decl. (J2000)                    | +14:15:43.15| (1)    |
| Parallax                         | 0.251 ± 0.032 mas | (1) |
| R.A. proper motion               | −6.599 ± 0.038 mas yr\(^{-1}\) | (1) |
| Decl. proper motion              | −17.148 ± 0.035 mas yr\(^{-1}\) | (1) |
| Radial velocity                  | −65.0 ± 1.0 km s\(^{-1}\) | (1) |
| Space velocity, ($U, V, W$)      | (−120, −290, −51) km s\(^{-1}\) | (2) |
| $V$                              | 9.490 ± 0.012 | (3) |
| $b - y$                          | 0.341 ± 0.007 | (3) |
| $m_1$                            | 0.044 ± 0.013 | (3) |
| $c_1$                            | 1.159 ± 0.018 | (3) |
| Reddening, $E(B - V)$            | 0.053 | (4) |
| Absolute magnitude, $M_V$        | −3.44 ± 0.27 | (5) |

**Note.**

Sources: (1) Gaia DR2; (2) space-velocity components relative to the Sun ($U$ toward the Galactic center, $V$ in direction of Galactic rotation, $W$ toward the Galactic north), calculated from Gaia astrometry and radial velocity; (3) this paper; (4) Stilism online tool (see the text); (5) this paper, calculated from data in this table (see the text).
precise astrometry of BD+14 is available from Gaia DR2, as given in Table 1. The measured parallax of 0.251 ± 0.032 mas, corrected by adding 0.029 mas (Lindegren et al. 2018), implies a distance of 3.57±0.46 kpc. Using the DR2 proper motion and radial velocity (RV), from rows 4, 5, and 6 of Table 1, I find a total space motion relative to the Sun of 318 km s\(^{-1}\), making BD+14 a star of very high velocity. The \(U, V, W\) components of the star’s space velocity relative to the Sun are given in row 7 of Table 1; these show that BD+14 is moving in a retrograde Galactic orbit.  

My measured V magnitude for BD+14, adjusted for the distance and reddening in Table 1, yields a visual absolute magnitude of \(M_V = -3.44 ± 0.27\). Figure 2 plots the position of BD+14 in the color versus visual absolute magnitude diagram (with \(b-y\) converted to \(B-V\) using the approximate relation \(b-y \simeq 0.69(B-V)\) from B80). To place the star in context, I also plot the color–magnitude diagram for the GC M79, taken from B16. As reported by B16, M79 contains a yellow PAGB star, and its position is also plotted in Figure 2. The figure shows that the M79 PAGB star, at \(M_V = -3.46\) (B16), has a nearly identical absolute magnitude to that of BD+14. Both stars lie some four magnitudes above the horizontal branch. However, BD+14 is cooler than the M79 PAGB star. The nominal location of the pulsational instability strip is indicated in the figure, and BD+14 appears to lie just within the blue edge of the strip. As noted below, it is in fact a low-amplitude variable.

The concordant visual absolute magnitudes found for BD+14 and the M79 star also agree very well with those of several more stars of this type known in GCs (Alves et al. 2001; B16, their Table 2; H. E. Bond et al. 2020, in preparation). All of them lie in the very narrow range \( -3.10 \geq M_V \geq -3.46\). Thus the properties of BD+14 appear to strengthen the case that yellow PAGB stars are good candidates for Population II standard candles.

5. Spectral-energy Distribution

Population I PAGB stars are typically associated with substantial amounts of circumstellar (CS) dust (e.g., van Winckel 2003; de Ruyter et al. 2006, hereafter deR06, and references therein). Dust is less commonly associated with Population II yellow PAGB stars like the ones discussed in this paper. HD 46703 has only a weak mid-infrared excess (Parhasarathy & Pottasch 1986; deR06), with an infrared (IR) luminosity of about 1% that of the photosphere. No IR excess has been detected for BD+39°4926 (deR06).

To test for the presence of CS dust around BD+14, I constructed its spectral-energy distribution (SED) from the following data: (1) GALEX (Morrissette et al. 2007) far- and near-UV fluxes; (2) magnitudes in the Sloan Digital Sky Survey bandpasses (ugriz) from the AAVSO Photometric All-Sky Survey (APASS); (3) my V magnitude (Table 1); (4) magnitudes in the 2MASS (Skrutskie et al. 2006) near-IR bands (\(J, H, K_s\)); and (5) magnitudes in the four WISE (Wright et al. 2010) mid-IR bands (3.4–22 \(\mu\)m). I corrected all of the measurements for reddening of \(E(B-V) = 0.053\), using the formulas of Cardelli et al. (1989), with a total-to-selective extinction ratio of \(R_V = 3.1\).

The resulting SED is plotted in Figure 3. For comparison I plot the flux for a blackbody with a temperature of 6000 K, based on the photometry as discussed in Section 3. This blackbody provides an excellent fit to the SED. No IR excess is seen out to 22 \(\mu\)m. The SED is very similar to that of the M79 PAGB star (B16, their Figure 6), which likewise shows no evidence for CS dust. As discussed by B16, dust formation may be difficult in low-metallicity stars, and also the relatively long post-AGB lifetimes of these low-mass remnants are likely to be long enough to allow any circumstellar dust to have dissipated. As also noted by B16, the absence of CS material indicates that stars like BD+14 and the M79 PAGB star are unlikely to produce ionized planetary nebulae during their later high-temperature evolutionary phases. The lack of extinction by CS dust is also favorable for the utility of these stars as standard candles.

9 Since there is some evidence, presented below, that BD+14 is a long-period spectroscopic binary, it is possible that binary motion has affected the Gaia astrometry, although to some extent the perturbation may have averaged out over the duration of the Gaia observations. The DR3 data release will provide further information on this concern.

10 However, in both GCs and the field, there are rare post–horizontal-branch stars, and post–early-AGB stars, that lie below the bright PAGB stars discussed here, and above the horizontal branch. (See, for example, Harris et al. 1983.) These include the Type II Cepheids and RV Tauri variables, as well as nonvariables outside the instability strip. These objects will be explored in detail in a forthcoming paper (B. D. Davis et al. 2020, in preparation). The Gaia parallax of HD 46703 suggests it may belong to this class of “above-horizontal-branch” stars, but the relative uncertainty of its parallax is high; thus its absolute magnitude is not well constrained. There is, in any case, an apparent sharp upper limit to the luminosities of the yellow PAGB stars in Population II systems.

11 https://galex.stsci.edu/GalexView/

12 https://www.aavso.org/apass

13 https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-scan?submit=Select&projshort=2MASS

14 https://irsa.ipac.caltech.edu/cgi-bin/Gator/nph-scan?submit=Select&projshort=WISE
As noted above and shown in Figure 2, BD+14 appears to lie within the pulsational instability strip, near its blue edge, in the color–magnitude diagram. The similar and prototypical star HD 46703 is a known pulsating variable star (e.g., Bond et al. 1984; Hrivnak et al. 2008, hereafter H08); its photometric behavior is complex, with a varying peak-to-peak amplitude of ~0.1–0.38 mag, and a typical period of about 29–31 days (H08).

To investigate whether BD+14 has similar light variations, I downloaded photometric data obtained by the All Sky Automated Survey (ASAS; Pojmanski1997). These observations are in the V band, and cover annual seasons from 2003 February to 2009 September. The ASAS light curves from these seven seasons are plotted in Figure 4.

As in the case of HD 46703, the star shows complex variations, with a peak-to-peak amplitude that can reach ~0.2 mag, but which sometimes nearly disappear. This suggests an interaction between several individual pulsation modes. A periodogram analysis indicates typical periods of about 30–32 days. BD+14 is thus remarkably similar in its pulsation properties to HD 46703. Both stars should perhaps be classified as members of the “UU Herculis” group of variable stars (see Sasselov 1984; Zsoldos 1993), but they lack the strong IR excesses seen in most stars of the UU Her class.

The mean magnitude for all of the ASAS observations is \( V = 9.39 \), with which my single measurement (Table 1) is in reasonable agreement.

### Photometric Variability

7. Radial Velocities

Both of the prototypical field old-population yellow PAGB stars mentioned in this paper are long-period single-lined spectroscopic binaries. For HD 46703, the orbital period is 597.4 days (Waelkens & Waters 1993; H08; O18), and for BD+14\(^{39+4296}\) it is 871.7 days (Kodaira et al. 1970; O18). The peak-to-peak RV amplitudes for these two stars are 33.7 and 30.6 km s\(^{-1}\), respectively. There is a substantial literature (e.g., O18 and references therein) that associates membership in a wide binary with the selective depletion of elements in PAGB stars’ atmospheres described above.

To check whether BD+14 is also a spectroscopic binary, I measured its RV on 32 nights over the interval from 2003 February 21 to 2011 September 11. Queue-scheduled spectrograms were obtained by Chilean service observers with the SMARTS\(^{16}\) 1.5 m telescope at CTIO, using its RC-focus spectrograph equipped with a CCD camera.

Two different grating setups were employed: (1) setting “56/l,” covering 4017–4938 Å, with a spectral resolution of 2.2 Å, and (2) setting “47/lb/,” covering 4070–4744 Å, with a spectral resolution of 1.6 Å. Exposure times each night were generally 3 × 75 s or 3 × 90 s, and short exposures of a HeAr calibration lamp were taken before and after each set of stellar observations.

The CCD images were reduced as described by B16 for their observations of the M79 PAGB star, which used the same telescope and spectrograph. The processing, spectrum extraction, and wavelength calibration were all done using standard IRAF\(^{17}\) routines.

In Figure 5, I show a spectrum created by combining all of the data for BD+14, and normalizing to a flat continuum. For comparison, I also plot the combined spectrum of the M79 PAGB star, taken from B16. The two spectra are nearly identical, showing sharp, strong absorption lines of the Balmer series. All of the metallic lines are quite weak in both stars. A high-dispersion analysis of the M79 star yielded [Fe/H] = −2.0 (Sahin & Lambert 2009), and the metallicity of BD+14 is likely to be similar.

I determined RVs from the spectra by cross-correlating with spectra of RV standard stars taken on many of the same nights, using the procedures described in detail in B16. The 1.5 m spectrograph was not highly optimized for precise RV measurements; the typical uncertainty of a single measurement is about ± 8–9 km s\(^{-1}\), with occasional larger outliers. Table 2

---

\(^{15}\) http://www.astrouw.edu.pl/cgi-asas/asas_variable/162949+1415.7, asas3.0,0.500,0.0

\(^{16}\) SMARTS is the Small & Moderate Aperture Research Telescope System; http://www.astro.yale.edu/smart.

\(^{17}\) IRAF was distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy (AURA) under a cooperative agreement with the National Science Foundation.
suggests that the RV may be variable. A periodogram analysis of the velocities, normalized to a flat continuum, yielded a most-likely period of about 430 days. I then applied a least-squares sinusoidal fit to the data, resulting in a period of \( P = 429.6 \pm 6.4 \) days, a semi-amplitude of \( K_1 = 7.5 \pm 2.0 \text{ km s}^{-1} \), and a center-of-mass RV of \( \gamma = -66.0 \pm 1.6 \text{ km s}^{-1} \). The \( \gamma \)-velocity is in good agreement with the median RV of \( -65.01 \pm 1.02 \text{ km s}^{-1} \) given by Gaia DR2. The bottom panel in Figure 6 shows the RVs phased with this period; superposed is the sinusoidal fit. Given the relatively large uncertainties in the individual velocities, the reality of the RV variations and this orbital period must be regarded as tentative. Nevertheless, the putative binary parameters are fairly similar to those of the prototypical field yellow PAGB stars.

For these binary parameters, the mass function is \( f(m) \simeq 0.019 M_\odot \). Assuming a mass for the PAGB star of \( m_1 \simeq 0.53 M_\odot \), I find a minimum mass for the unseen secondary of \( m_2 \simeq 0.22 M_\odot \). Thus, the nature of the companion is fairly unconstrained; it could be a main-sequence star, or possibly a white dwarf.

**8. Summary**

In this paper I report my discovery, based on Strömgren photometry showing a very large Balmer discontinuity, that the metal-poor Galactic-halo field star BD+14°3061 is a member of the rare class of yellow PAGB stars. From its Gaia DR2...
parallax, I find a visual absolute magnitude of \(-3.44 \pm 0.27\). This is close to the absolute brightness of a similar luminous star in the globular cluster M79, and supports the case that yellow PAGB stars may be useful Population II standard candles.\(^\text{18}\) The Gaia parallax and proper motion show that BD +14 has a very high space motion of 318 km s\(^{-1}\), and moves in a retrograde Galactic orbit. The spectral-energy distribution of BD+14 out to 22 \(\mu\)m shows no evidence for circumstellar dust. Archival photometry reveals that BD+14 is a low-amplitude semiregular pulsating variable, similar to the UU Herculis class, with typical periods of 30–32 days. A radial-velocity study indicates a possible binary period of 429.6 days, which would make BD+14 similar to several other known long-period binaries among PAGB stars.

Useful future studies would include a high-dispersion abundance analysis, and confirmation of the binary period using more precise radial velocities. A more precise parallax from Gaia DR3 will strengthen its utility as a zeropoint calibrator for yellow PAGB stars as standard candles.

I was motivated to publish this ancient discovery through discussions with Robin Ciardullo, Brian Davis, and Michael Siegel. Penn State undergraduate Ben Hampton carried out some of the radial-velocity data reduction. My research on metal-deficient stars in the 1970s at Louisiana State University was partially supported by National Science Foundation grant AST 78-25538.

I thank the STScI Director’s Discretionary Research Fund for supporting participation in the SMARTS consortium, and Fred Walter for scheduling the 1.5 m queue observations. I especially appreciate the excellent work of the CTIO/SMARTS service observers who obtained the spectra during many long clear Tololo nights: Sergio González, Manuel Hernández, Rodrigo Hernández, Alberto Pasten, and José Velásquez. Daniel Maturana was my cheerful night assistant for the CTIO 0.9 m photometry.

This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia MultiLateral Agreement.

This work is based in part on observations made with the NASA Galaxy Evolution Explorer. Gaia was operated for NASA by the California Institute of Technology under NASA contract NAS5-98034.

This research used data from the AAVSO Photometric All-Sky Survey (APASS), funded by the Robert Martin Ayers Sciences Fund and NSF AST-1412587.

This publication makes use of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation.

It also makes use of data products from the Wide-field Infrared Survey Explorer, which is a joint project of the University of California, Los Angeles, and the Jet Propulsion Laboratory/California Institute of Technology, funded by the National Aeronautics and Space Administration.

**ORCID iDs**

Howard E. Bond @ https://orcid.org/0000-0003-1377-7145

**References**

Alves, D. R., Bond, H. E., & Onken, C. 2001, AJ, 121, 318

Bartkevicius, A. 1992, BaltA, 1, 194

Bond, H. E. 1980, ApJS, 44, 517, (B80)

Bond, H. E. 1991, in IAU Symp. 145, Evolution of Stars: the Photospheric Abundance Connection, ed. G. Michaud & A. Tutukov (Kluwer: Dordrecht), 341

Bond, H. E. 1997a, in IAU Symp. 180, Planetary Nebulae, ed. H. J. Habing & H. J. G. L. M. Lamers (Dordrecht: Kluwer), 460

Bond, H. E. 1997b, in The Extragalactic Distance Scale, ed. M. Livio, M. Donahue, & N. Panagia (Cambridge: Cambridge Univ. Press), 224

Bond, H. E., Carney, B. W., & Grauer, A. D. 1984, PASP, 96, 176

Bond, H. E., Ciardullo, R., & Siegel, M. H. 2016, AJ, 151, 40, (B16)

Capitanio, L., Lallement, R., Vergely, J. L., et al. 2017, A&A, 606, A65

Cardelli, J. A., Clayton, G. C., & Mathis, J. S. 1989, ApJ, 345, 245

Crawford, D. L. 1975, PASP, 87, 481

de Ruyter, S., van Winckel, H., Maas, T., et al. 2006, A&A, 448, 641, (deR06)

Gaia Collaboration, Brown, A. G. A., Vallenari, A., et al. 2018, A&A, 616, A1

Harris, H. C., Nemec, J. M., & Hesser, J. E. 1983, PASP, 95, 256

Hrivnak, B. J., Van Winckel, H., Reyniers, M., et al. 2008, AJ, 136, 1557, (H08)

Kodaira, K., Greenstein, J. L., & Oke, J. B. 1970, ApJ, 159, 485

Lindegren, L., Hernández, J., Bombrun, A., et al. 2018, A&A, 616, A2

Luck, R. E., & Bond, H. E. 1984, ApJ, 279, 729, (LB84)

Morrissey, P., Conrow, T., Barlow, T. A., et al. 2007, ApJS, 173, 682

Oomen, G.-M., Van Winckel, H., Pols, O., et al. 2018, A&A, 620, A85, (O18)

Oomen, G.-M., Van Winckel, H., Pols, O., et al. 2019, A&A, 629, A49

Parthasarathy, M., & Pottasch, S. R. 1986, A&A, 154, L16

Philip, A. G. D., & Philip, K. D. 1973, ApJ, 179, 855

Pojmanski, G. 1997, AcA, 47, 467

Rao, S. S., Giridhar, S., & Lambert, D. L. 2012, MNRAS, 419, 1254

Reylea, L. J., & Kurucz, R. L. 1978, ApJS, 40, 45, (RK78)

Şahin, T., & Lambert, D. L. 2009, MNRAS, 398, 1730

Sasselov, D. D. 1984, ApJSS, 102, 161

Skrutskie, M. F., Cutri, R. M., Stiening, R., et al. 2006, AJ, 131, 1163

van Winckel, H. 2003, ARA&A, 41, 391

Waellken, C., & Waters, L. B. F. M. 1993, in ASP Conf. Ser. 45, Luminous High-Latitude Stars, ed. D. D. Sasselov (San Francisco, CA: ASP), 219

Wright, E. L., Eisenhardt, P. R. M., Mainzer, A. K., et al. 2010, AJ, 140, 1868

Zooltov, E. 1993, A&A, 280, 177

---

\(^{18}\) As the referee points out, if BD+14 is a binary with the period discussed here, its evolution should have been truncated by binary interactions and mass loss. Since the luminosities of PAGB stars are a function of core mass, such interruptions of their evolution will have imposed limits on their absolute magnitudes, which should vary from star to star. Nevertheless, the \(M_p\) of BD+14 agrees very well with that of the yellow PAGB star in M79 (Figure 2), and with other such stars in GCs, as will be shown in forthcoming papers. Rigorous empirical tests will be required to establish yellow PAGB stars as standard candles for distance determination.