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Asymptotic Giant Branch Variables in NGC 6822

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Abstract. Multi-epoch JHK_S photometry is used to identify large amplitude variables and to study the AGB population of NGC 6822. 50 Mira variables, ranging in period from 128 to 998 days, have been identified. The majority of these are around 1 to 4 Gyr old, but a significantly younger component is also identified.

Keywords. stars: AGB and post-AGB, stars: carbon, stars: variables: other, galaxies: individual: NGC 6822, galaxies: stellar content, (galaxies:) Local Group

1. Introduction

NGC 6822 is a barred dwarf irregular in the Local Group, at a distance of about 490 kpc. A recent summary of what is known about its various populations is provided by Gouliermis *et al.* (2010).

The observations discussed here form part of a study of AGB stars in Local Group galaxies and detailed analysis have been published for the Phoenix, Leo I and Fornax dwarf spheroidals by Menzies *et al.* (2008, 2010) and Whitelock *et al.* (2009). A preliminary study of the variables in NGC 6822 was made by Nsengiyumva (2010) for his MSc thesis, but the detailed analysis is still underway, and this account highlights only a few preliminary findings.

2. Observations

We observed NGC 6822 with the SIRIUS camera on the Infrared Survey Facility (IRSF) at SAAO Sutherland. This provides simultaneous JHK_S images with a frame size of approximately $7'.2 \times 7'.2$ after dithering. Three frames, orientated north south, were used to cover the central part of the galaxy, and observations were made on 19 epochs (16 for the most southerly frame) spread over 4 years.

Colour magnitude diagrams (K_S vs. $J - K_S$) of our data were presented by Nsengiyumva (2010) and by Whitelock (2011). Because NGC 6822 is at a relatively low Galactic latitude, $b \sim -18^o.4$, there is a good deal of contamination, and the majority of the stars with $J - K_S < 1.0$ are in the foreground of NGC 6822.

3. Asymptotic Giant Branch (AGB) Stars

Letarte *et al.* (2002) obtained four-colour photometry (R, I, CN, TiO) of about 65 000 stars in NGC 6822, many of which are in common with our sample. Using the method illustrated in fig. 3 of Letarte *et al.* we can distinguish between M and C stars and Fig. 1 here illustrates the positions of these two groups on a colour-magnitude plot that shows only the stars in common with Letarte *et al.*

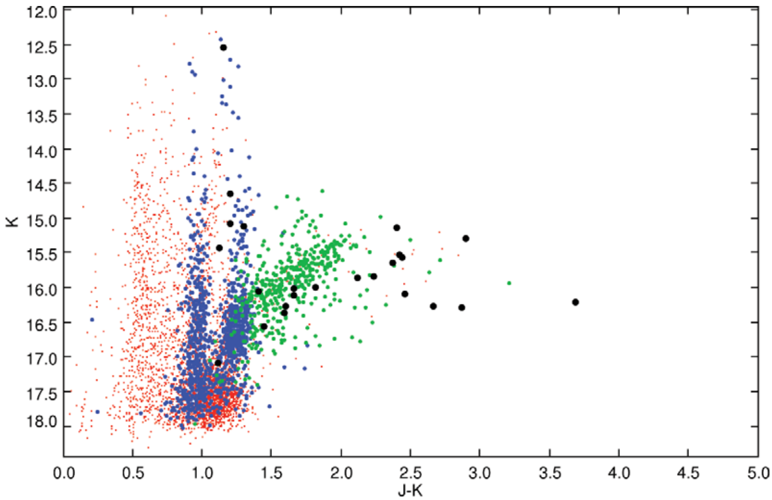

Figure 1. Colour-magnitude diagram of stars in common with Letarte *et al.* (2002); blue points and green points represent stars with M- and C-type spectra respectively, while large black circles are large amplitude variables.

We see two plumes of M-type stars at $J - K_S \sim 0.9$ and ~ 1.3. The first group is mostly foreground stars, while the second comprises almost entirely AGB stars, with a sprinkling of red supergiants at $K_S < 13$; note that the tip of the red giant branch is at $K_S \sim 17.1$ (Cioni & Habing 2005). The AGB stars are a combination of (1) relatively early AGB stars that will evolve into C stars, (2) a few old metal-weak stars, similar to those found in Galactic globular clusters and (3) luminous, $K_S < 16$, M stars that had relatively massive, $M > 4M_\odot$, progenitors; these may have avoided becoming C-rich through hot bottom burning. It is possible that a few of the extreme AGB stars with very red colours may be OH/IR stars, i.e. have M-type spectra, but infrared spectra will be required to establish that, one way or the other.

Most of the C-stars have $J - K_S > 1.4$, although there are a few with colours that overlap those of the M stars, and fall on the extended AGB, a phase through which most metal-deficient intermediate-mass stars are thought to evolve. Note that the reddest of the variables found in our sample (and illustrated in the colour-magnitude diagrams of Nsengiyumva (2010) and Whitelock (2011)) are too faint at shorter wavelengths to have been measured by Letarte *et al.*, and are therefore not illustrated here.

4. Variables

Nsengiyumva (2010) describes how the variable stars were selected. Most of those with large amplitudes, $\Delta K_S > 0.4$ mag, are Mira variables. Although there is at least one red supergiant and a long period Cepheid (see Whitelock 2011) with comparable amplitudes, their positions in the colour magnitude diagram distinguish them from the AGB stars.

Fig. 2 illustrates the light curves for the shortest (P = 158 days) and longest period (P = 998 days) stars found during this preliminary analysis, while Fig. 3 shows a histogram of the 50 Miras for which periods have so far been determined. Battinelli & Demers (2011) also examined NGC 6822 for variables using K_S images over a somewhat larger area and identified 33 Miras; their period distribution is comparable to ours. There are 13 variables in common between these two samples, and obviously a large number of Miras are yet to be discovered, given that the old and intermediate age populations are

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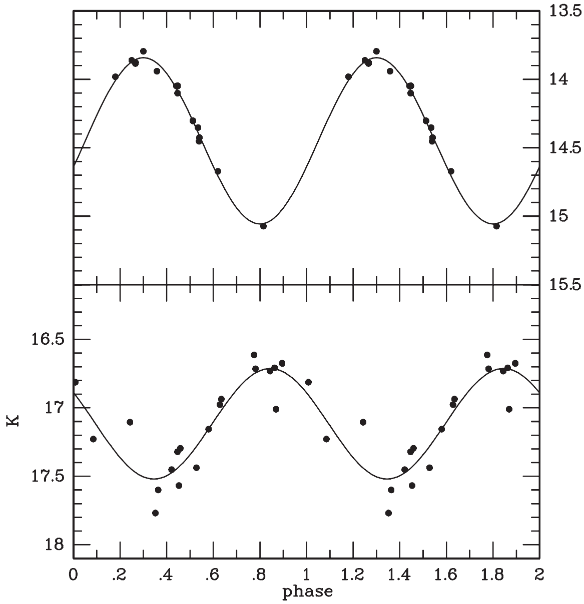

Figure 2. Light curves for the longest (top) and shortest (bottom) period AGB stars phased at their periods of 998 and 158 days, respectively. The curves are the best fitting first order sine curves.

known to spread over a degree (de Blok & Walter 2006). The P = 158 day star has an M-type spectrum according to its colours from Letarte *et al.*, while the P = 998 day one was not measured by them.

The majority of the Miras have periods in the range $200 < P < 500$ days and therefore ages approximately in the range 4 to 1 Gyr. There are only two stars with periods below 200 days, possibly because these are fainter and more difficult to find. There is, however, a very clear tail of longer period stars representing a small younger population. These are missing from the dwarf spheroidals (Menzies *et al.* 2008; 2010; Whitelock *et al.* 2009), as might be expected given their commonly accepted star formation histories (although note that the total number of stars in the dwarf spheroidals is much smaller than in NGC 6822).

Fig. 4 shows all the large amplitude variables on a period-luminosity plot, with symbol colours that represent the mean $J - K_S$ of the star according to the scale on the right side of the plot. It is clear that the redder stars are much fainter than their bluer counterparts

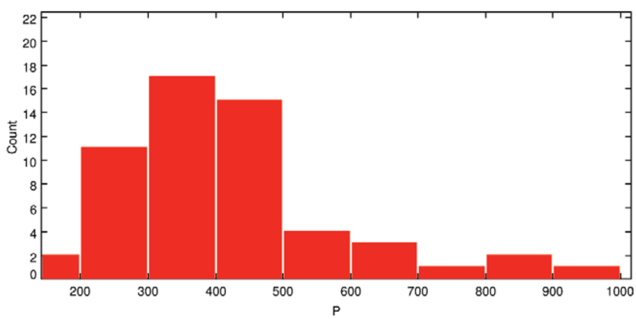

Figure 3. A histogram of the periods of the large amplitude (Mira) AGB variables.

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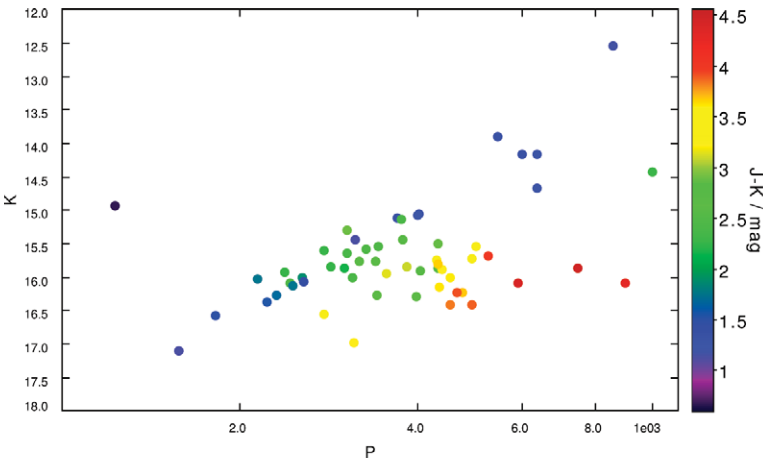

Figure 4. A period-luminosity plot for the large amplitude variables, with coloured symbols indicating the mean $J - K_S$ as illustrated on the right-hand side. The bright short period star is a Cepheid and the bright long-period star is probably a red supergiant.

at the same period. This is a consequence of thick circumstellar shells causing significant obscuration in the K_S band.

Nsengiyumva (2010) estimated bolometric magnitudes of a subset of this sample that are probably C-rich, using a colour-dependent bolometric correction. He found that the stars obeyed a period-luminosity relation that was very similar to the one followed by C-stars in the LMC and dwarf spheroidal galaxies.

Kniazev *et al.* (2009) used these same IRSF data, combined with spectroscopy from SALT, to identify the first symbiotic system in NGC 6822. The cool component of this binary is a semi-regular carbon-rich AGB variable, pulsating in the first overtone with a period of 142 days. It is losing mass to a white dwarf companion.

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