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AGB variables in the field of Gamma Cas

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Abstract. We selected AGB candidate stars in a 25 square degrees region centered at l=123 b=-2, along the galactic plane, using the r-i color index of the IPHAS survey. Historic light curves in the photographic I band were derived from digitized plates of the Asiago Observatory and spectral types were obtained from slit spectroscopy at 5 A resolution. Twentytwo variables were found, doubling the number of known variables in the region. Seven of these variables are Carbon stars, none of which is a regular Mira. Nine stars are Miras and five stars show long term trends. From magnitude-period relation an average distance of 3.2 kpc was found but with a large scatter.

Key words. Stars: variables – Stars: Mira – Stars: Carbon stars

1. Introduction

AGB stars are good tracers of a stellar population and can be seen at large distances given their high luminosity. We report a photometric search for variable candidate AGB stars in a 5 degrees wide field on the galactic plane centered on Gamma Cas (l=123, b=-2) using 90 plates taken with the Asiago Schmidt telescope in the years 1967-1975 in the Cousins I band (I-N emulsion + RG5 filter). The limiting magnitude is about 16. The time sampling is rather uniform and allows a good period determination for long period (Mira) variables as well as the detection of period changes. Plates were scanned at the Perugia University with an EPSON 1680 Pro at 1600 dpi in transparency mode (Nesci et al. 2014). Astrometry and photometry was made with the APPLAUSE pipeline (Tuvikene et al. 2014) using the UCAC-4 (Zacharias et al. 2013) sloan I-band magnitudes for comparison.

2. Sample selection

The IPHAS DR2 catalog (Barentsen et al. 2014) is a single-epoch CCD survey of the Northern galactic plane made with Isaac Newton 2.5m telescope at La Palma in the r',i' and H-alpha bands down to i'$\sim$20 mag. It contains nearly 63000 stars brighter than i'=15 mag in our field. The color-color plot (Fig.1) of the stars with high-quality flag (a10point=1) shows the typical finger-like pattern due to the different reddenings of distinct stellar populations along the line of sight. The upper sequence is the locus of the foreground less-reddened stars, with spectral types running from A (lower left) to M (upper right). The

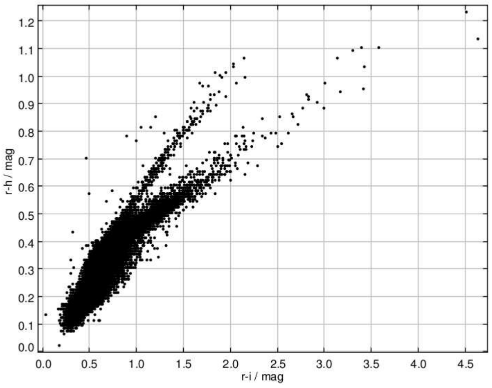

Fig. 1. The color color diagram of the 25000 "high-quality flag" stars brighter than i=15 in the IPHAS catalog in our field.

lower, much more populated, sequence contains more reddened stellar populations. Strong emission line stars have larger r-h value, so are located above the normal stars sequences. About 530 AGB candidate stars were selected from this sample adopting r'-i'>1.7, so most of them belong to the reddened population.

3. Photometry and spectroscopy

Stars on the plates are detected with Sextractor and their magnitudes measured with MAG-AUTO. Photometric comparison sequences were taken from the UCAC4 i' band catalog. The average photometric accuracy is 0.15 mag, so we considered as variables only stars with an rms deviation of the individual measures from the mean > 0.3 mag. The light curves of two stars are shown in Fig. 2 and Fig. 3.

Out of 530 stars selected, 22 appeared to be surely variable and only 13 of them were already known in the VSX catalog. We classified the light curves in 4 groups: a) Mira = regular period, constant large amplitude (9 stars, see e.g. Fig. 2); b) LPV = large amplitude, less regular period/amplitude (4 stars); c) Trend = variable average magnitude (5 stars, see e.g. Fig.3); d) Irregular= small amplitude, no period (5 stars).

Nearly all our variables are in the locus of the most reddened stars of Fig.1.

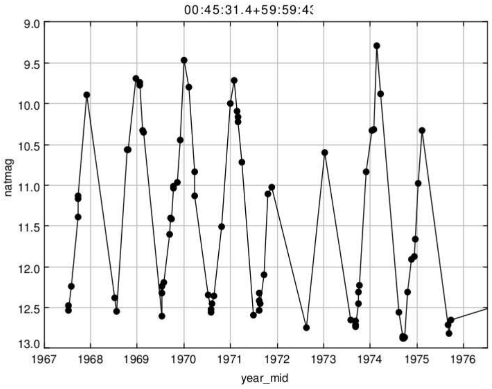

Fig. 2. Light curve of the star 00:45:31.4 +59:59:43, a regular Mira variable.

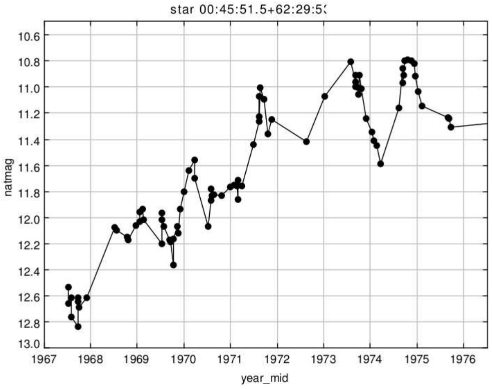

Fig. 3. Light curve of the star 00:45:51.5 +62:29:53 showing a long-term trend

Spectroscopic follow-up of all the variables and of a subsample (r-i>2) of non-variables was performed at 5 A resolution with BFOSC at the 1.5m telescope of Loiano, and AFOSC at the 1.8m telescope of Asiago.

The spectral types ranged from M1 to M8, with 7 stars of C type, all but one with optical spectral evidence of a circumstellar envelope. Five stars have spectra almost identical to those of known S type stars, although the spectral resolution does not allow to clearly detect the details that definitely characterise this spectral type.

Fig. 4 shows the locations of our variables in the IPHAS r-i,r-h color-color plot with the spectral types and variability class

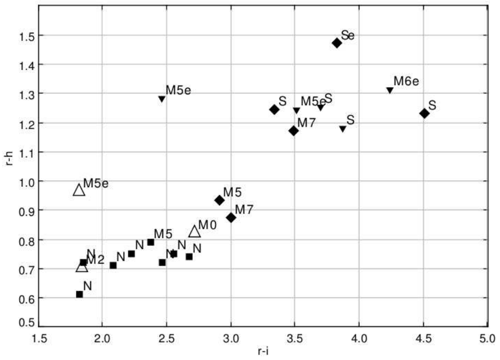

Fig. 4. Spectral types of the variable stars in the IPHAS color-color plot. The variability class is coded as: Mira = diamonds, LPV = filled triangles; irregulars = open triangles; long-term trend = squares. Carbon stars are clearly separated by the S-type ones, M-type lying in between.

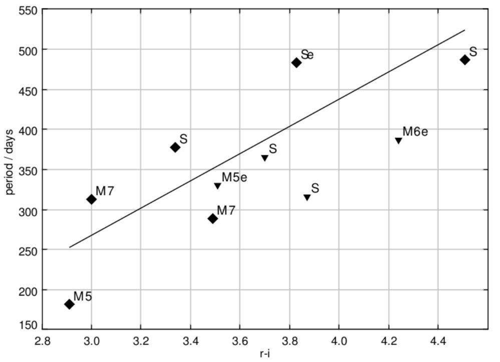

Fig. 5. Period vs r-i color index for the stars with a good period determination: diamonds = Miras; triangles = LPVs.

marked (Mira, LPV, irregular, long term trend). Remarkably, all the Carbon stars showed long term trends in their light curve, while no clear correlation was found for M and S stars between spectral type and variability class.

We looked for a (color index) - Period correlation for stars classified as Mira and LPV (see Fig. 5) but the interpretation of our finding is not obvious. Discriminating between fundamental and first overtone pulsators could be useful, but needs further better sampled light curves.

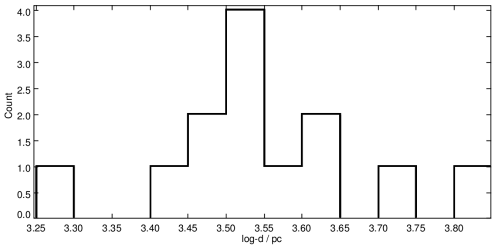

Fig. 6. Histogram of the distance determinations based on the Period-absolute magnitude in K band.

4. Distances

For the Mira stars we evaluated their distance from the Period-K-magnitude relation (Knapp et al. 2003): K magnitudes were taken from 2MASS catalog and were corrected for the expected extinction (A_V=1.4) in this direction at the distance of the Perseus spiral arm taken from Sale et al. (2014). The average value of the computed distances is about 3300 pc but with a large spread: the LPV are more strictly grouped near the average value, while the Miras have a substantially larger spread, as if they were distributed between the Perseus spiral arm and the outer arm (see Fig. 6): a detailed evaluation of the actual extinction for each star should be made to derive more reliable results.

We expect that for many of our stars a trigonometric distance measure by GAIA will be available with the next catalog releases. These direct measures will allow a better estimate of the interstellar and circumstellar absorption for our stars and therefore a better evaluation of their evolutionary status.

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