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The OH/IR star population at the centre of the Galaxy

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Abstract. In the last years various OH surveys at 1612 MHz have been carried out in the galactic bulge region with high spatial resolution (Lindqvist et al. 1992; Sevenster et al. 1997; Sjouwerman et al. 1998) which have resulted in the detection of over five hundred double-peaked objects commonly associated with oxygen-rich AGB stars. More recently, the ISOGAL survey, which is part of the ISO mission, scanned several regions along the galactic plane, including the inner bulge, at 6.8 and 15 micron wavelengths. In this work we report an analysis of 104 OH/IR stars in the bulge, based on near and mid-infrared observations. Mass-loss rates, luminosities and masses are determined for a sub-sample of stars, for which near-infrared data are available in the literature.

1. Introduction

Lindqvist et al. (1992), Sevenster et al. (1997) and Sjouwerman et al. (1998) surveyed the galactic bulge at high spatial resolution and found altogether over five hundred double peaked OH sources at 1612 MHz frequency. Most sources are concentrated in the central degree of the bulge, in a region severely obscured by interstellar extinction. The detection of near-infrared counterparts and multi-band photometric measurements were carried out by Wood et al. (1998), which also obtained K-band light curves, and Blommaert et al. (1998).

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Type-II OH masers are generally associated with high mass-loss rate ($\dot{M} > 10^{-7} M_{\odot}$/year) AGB stars in the thermal-pulse phase. Their circumstellar envelopes are optically thick and most of the luminosity is radiated at wavelengths beyond 2 micron. For these stars mid-infrared photometry is especially important to determine their luminosities. The ISOGAL survey (Pérault et al. 1996) covered a significant fraction of the inner bulge at two wavelengths: 6.8 and 15 micron at high sensitivity and astrometric accuracy. For more details about the observations the reader should refer to Pérault et al. 1996 and Ortiz et al. 2000.

In this work we report a study of OH/IR stars in the inner part of the bulge, observed by ISOGAL. Magnitudes and colours are presented in section 2 and the determination of masses and luminosities is described in section 3.

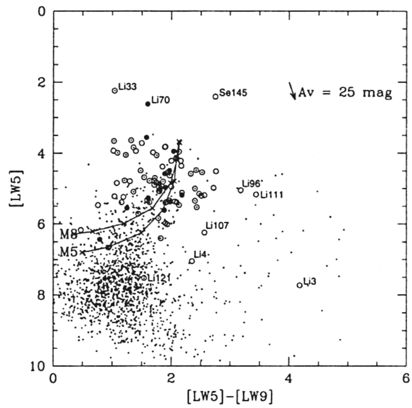
2. Magnitudes and colours

Because of problems caused by the saturation of the images by very bright sources, ISOGAL avoided the region very close to the galactic centre. 104 OH sources taken from the lists of Lindqvist et al., Sevenster et al. and Sjouwerman et al. were detected in the ISOGAL survey, corresponding to the detection rate of 100 %. The complete list of sources, including their names, LW5 and LW9 magnitudes and positions can be found in Ortiz et al. (2000).

Figure 1 shows the colour-magnitude diagram for all sources observed both at $\lambda = 6.8$ and 15 micron. Filled circles represent simultaneous measurements and open circles refer to observations carried out at different epochs. The lines represent the results of a model for circumstellar envelopes developed by Groenewegen (priv. commun.) for giants of M5 and M8 spectral types. Along the lines, the mass-loss rate increases from 10^{-8} to $10^{-5} M_{\odot}$/year. The sources are found spread over a wide range of colour, however the ones observed at the same time in the two filters follow the predictions of the model more closely than those observed non-simultaneously. This discrepancy might mean that variability plays an important role in these stars. It is also possible that some of the redder stars are in the beginning of the post-AGB phase, when the degenerate core of the star becomes exposed but the OH molecules are still protected against ultraviolet radiation by the star's thick shell.

3. Luminosity of OH/IR stars in the bulge

To obtain bolometric magnitudes we integrated the distribution of energy considering extinction-corrected near-infrared and ISOGAL magnitudes. The interstellar visual extinction to the galactic centre is given by Schultheis et al. (1999) and the values for the infrared bands were obtained using A_{λ}/A_V conversion factors by Koornneef (1983). The calculation of the flux radiated in the visible range is performed assuming a blackbody spectrum fitted on the two bluest bands (usually J and H) available for each source. For the mid-to-far infrared flux we assume a power-law spectrum fitted on the ISOGAL flux densities. The power of the spectrum varies from source to source and it is a function of the ([LW5]-[LW9]) colour index. To convert the bolometric magnitudes into luminosities we assume the distance modulus of the galactic centre m-M=14.5,



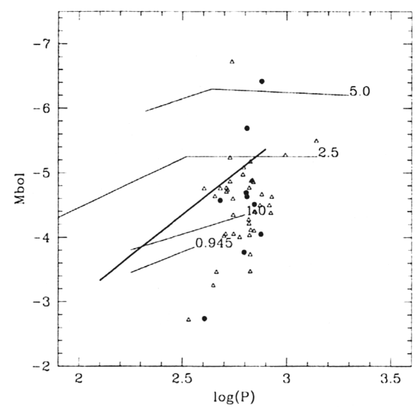


Figure 1. Left, color-magnitude diagram of OH/IR stars in the bulge. Open circles represent measurements taken at different epochs and the filled circles were obtained at the same date. The curves are the predictions of a model for increasing mass-loss.

Figure 2. Right, period-luminosity diagram of OH/IR stars in the bulge. Filled circles: photometry by Blommaert et al. (1998); triangles: photometry by Wood et al. (1998); thin lines: iso-mass curves (VW); thick line: PL relationship (Glass et al. 1995).

which corresponds to the distance of 7.9 kpc. Only stars with near-infrared **and** ISOGAL magnitudes were considered.

Figure 2 shows absolute bolometric magnitudes plotted against the period of the star by Wood et al. (1998). The straight line is the period-luminosity (PL) relationship derived by Glass et al. (1995) for long period variables (LPV's) in the bulge and the thin lines represent iso-mass curves, according to the model by Vassiliadis & Wood (VW, 1993). Although the iso-mass curves are designed for solar and sub-solar chemical abundances, they can provide us an approximate mass range of the AGB population in the bulge.

The luminosities are spread over a wide range, from $1 \times 10^3 L_\odot$ up to $5 \times 10^4 L_\odot$, with a peak at $5 \times 10^3 L_\odot$. Most stars are located below the PL line. This can be interpreted as the stars have longer periods than expect by the PL relation derived for LPV's due to the change of the pulsation mode from the first overtone to fundamental as the star enters the thermal pulse phase. Similarly, the stellar mass distribution is also very wide: the vast majority of the stars have $M < 2.5 M_\odot$. In the sample studied, stars do not show a clear correlation between their pulsation periods and masses as proposed by others (Jura & Kleinmann 1992), however since the model by VW is not designed for the wide range of metallicities existing in the bulge the stellar masses might be badly estimated.

4. Conclusions

The study of 104 OH/IR stars in the bulge observed in the near and mid-infrared shows that the stars have high mass-loss rates, in the range $10^{-7} \sim 10^{-5} M_{\odot}$/year. Most of them are variable and pulsate in the fundamental mode. As a consequence, the stars are located below the period-luminosity relationship commonly derived for miras. The sample studied shows a very wide luminosity range, peaked at $5 \times 10^3 L_{\odot}$ and their masses are tipically less than $2.5 M_{\odot}$.

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