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The RMS Survey: A Systematic Search for Massive Young Stars in the Galaxy

M. G. Hoare, S. L. Lumsden, R. D. Oudmaijer, A. L. Busfield and T. L. King

Department of Physics and Astronomy, University of Leeds, Leeds, LS2 9JT, UK

T. L. J. Moore

Astrophysics Research Institute, Liverpool John Moores University, Twelve Quays House, Egerton Wharf, Birkenhead, CH41 1LD, UK

Abstract.

We have selected red MSX sources (RMS) that have the colours of massive young stellar objects (MYSOs). Our aim is to generate a large, systematically selected sample to address questions such as their luminosity function, lifetimes, clustering and triggering. Other objects such as UCHIIs, PN, PPN and AGB stars have similar IR colours and a large programme of ground-based follow-up observations is underway to identify and eliminate these from the sample of the red MSX sources. These include radio continuum observations, kinematic distances, ground-based mid-IR imaging, near-IR imaging and spectroscopy to distinguish. We report the progress of these campaigns on the 3000 candidates, with initial indications showing that a substantial fraction are indeed massive YSOs.

1. Introduction

Studies of massive star formation are currently hampered by the lack of large systematically selected samples of objects in the earliest phases. Any well-selected sample of massive YSOs must start from the IR where most of their bolometric luminosity emerges. IRAS data has previously been used (e.g. Campbell et al. 1989; Chan et al. 1996; Sridharan et al. 2002), but its large beam size means that it is often confused in the galactic plane. The MSX survey of the plane in the mid-IR (Price et al. 2001) provides much better spatial resolution and virtually eliminates any bias against the dense and clustered environments where MYSOs are.

We have developed colour-cuts ($F_{21} > 2F_8$ and $F_8 < F_{14} < F_{21}$) to select MYSO candidates from the MSX PSC with additional colour-cuts ($F_8 > 5F_K$ and $F_K > 2F_J$) using the 2MASS near-IR survey (Lumsden et al. 2002). These colour-cuts and the elimination of known sources leaves a sample of about 1700 (leaving out the crowded galactic centre region). This sample still contains many other objects such as compact H II regions, PN, PPN, AGB stars, etc., which

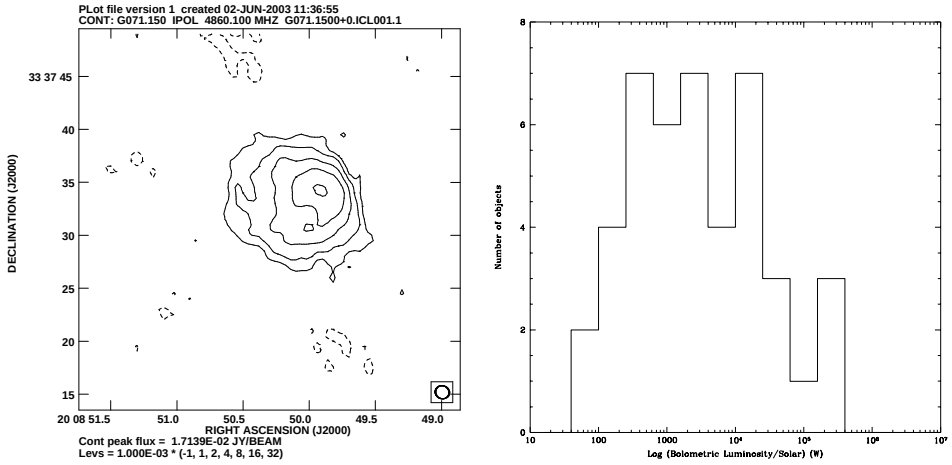

Figure 1. a) Example of a compact, cometary H II region found in the RMS sample. b) Luminosity distribution of a sample of outer galaxy RMS sources with good IRAS fluxes.

have the same IR colours. Our follow-up programme of observations is designed to identify and eliminate these.

2. The RMS Survey Follow-Up Programme

The main overlap is with compact H II regions, which are of course also young massive stars in the phase immediately following the MYSO phase. These (and PN) are most easily identified by their strong radio continuum emission compared to the weak emission from the stellar winds of MYSOs (Hoare 2002). We are therefore observing every candidate at 1 $''$ resolution at 5 GHz. 500 targets have been observed to date with about 20% of objects detected, e.g. Figure 1a. The remaining radio-quiet objects are kept as MYSO candidates.

To determine luminosities we are obtaining kinematic distances from observations of ^{13}CO and have so far observed 500 sources. Figure 1b is the luminosity distribution for a sub-sample of outer galaxy sources, which clearly shows a substantial fraction of the sources have luminosities consistent with early-type stars.

we are carrying out ground-based mid-IR imaging to check for extended and/or multiple point sources within the 18$''$ MSX beam. So far around 300 targets have been observed with about 10% revealed as extended sources, mostly likely compact H II regions or PN. This is also the best way to identify MYSOs close to or superimposed upon compact H II regions themselves.

Near-IR K-band images of around 400 targets have been obtained to help identification and as a prelude to IR spectroscopy. About 80% are consistent with young star forming regions in that they show nebulosity, clusters and/or extinction. Figure 2a shows the near-IR image of one of our strong MYSO candidates. The near-IR spectrum of this source (Figure 2b) is red and featureless consistent with that of many MYSOs. Our spectroscopy programme will also

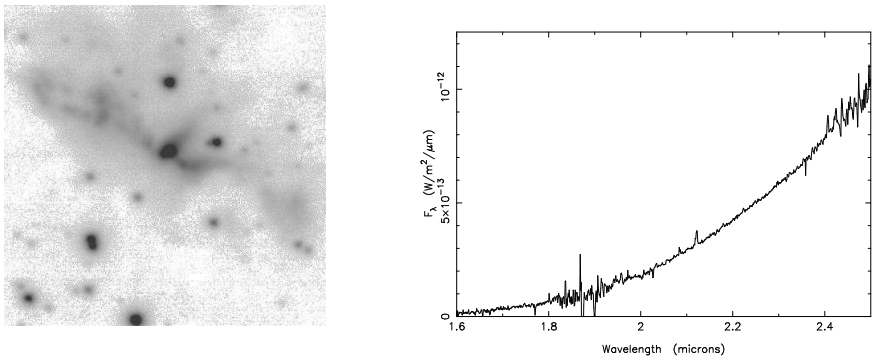

Figure 2. a) Near-IR K-band image of one strong MYSO candidate showing a probably bipolar nebula, extinction and associated cluster. b) Near-IR spectrum of the central source in a). Note the very red, feature-less continuum characteristic of MYSOs. The 2.12μm H_2 line is visible and this and other shock excited lines are strong along the length of the outflow. The range 1.80μm$< \lambda <$ 1.95μm and $\lambda >$ 2.39μm are affected by noise due to the atmosphere.

reveal any remaining cooler post-MS objects that mimic MYSO characteristics in other ways.

3. Conclusions

The RMS survey is clearly finding large numbers of new MYSOs. We currently estimate that we will deliver a well-selected sample of order 500 MYSOs with L$> 10^4 L_\odot$. This is an order of magnitude larger than that currently known and will be close to being complete for the galaxy at the higher luminosities. This number is consistent with a simple estimate of the expected total number of MYSOs in the galaxy based on the accepted star formation rate, an assumed IMF and phase lifetime (Lumsden et al. 2002).

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