Compact Mid-IR Emission from High-Mass Protostellar Candidates

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INTRODUCTION

The number of known high-mass protostellar objects (HMPOs) is small because high-mass stars are rare and their evolutionary time scales are short. The theory of high-mass star formation is not as well established as that of low-mass star formation partly because of the small number of candidate HMPOs. Van der Tak et al. (2000) have recently studied the envelopes around UC HIIs and hot cores, and Molinari et al. (1996) have defined and studied a sample of candidate HMPOs.

Shridahran et al. (2002) and Beuther et al. (2002) give initial results of a separate study of 69 "relatively isolated" HMPO candidates. These were selected from bright IRAS FIR sources ($F_{100} >$ 500 Jy), previously detected in a CS survey, with weak radio continuum emission (<25 mJy) in single dish surveys.

Sridharan et al. obtained IRAS HIRES images and MSX mid-IR images of the HMPO candidates. They reported radio continuum observations at 3.6 cm with the VLA B array, and observations of various molecular lines. Most objects had very weak cm fluxes, so they should be younger than massive stars with UC HIIs. Beuther et al. show maps of them in 1.2 mm dust continuum with the IRAM 30 m telescope.

The MSX mid-IR images, and the 1.2 mm IRAM images have spatial resolutions of 18.3" and 11" respectively. The 1.2 mm images trace dust in molecular cores which have formed clusters of stars, or perhaps isolated HMPOs.

The spatial distribution of the mid-IR emission is unknown based on IRAS and MSX images. It could be extended on a scale similar to the molecular cores or concentrated at the location of a single HMPO.

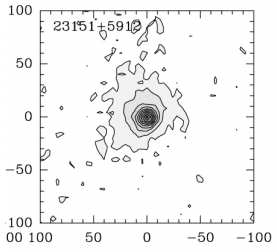

Fig. 1. 1.2 mm continuum map of IRAS 23151+5912 made with an 11" beam (Beuther et al. 2002). The source size is 16.5" □ 14.4" FWHM. (0,0) is at the IRAS position. The field of view is 200".

INTRODUCTION (Cont'd)

We have imaged four of the Sridharan et al. HMPOs at a resolution of ~1" with MIRSI on the IRTF to search for compact emission in the 10 and 20 □m atmospheric windows. Our selection criteria were compact 1.2 mm and MSX emission.

Three were detected at both 10 and 20 □m. One was detected only at 10 □m.

OBSERVATIONS AND RESULTS

The B.U. Mid-Infrared Spectrometer and Imager (MIRSI) was used on the IRTF during engineering time for the camera in November 2003 for the observations. Wide band filters in the 10 and 20 □m windows were used to search for compact sources or extended emission.

Compact sources were observed at both wavelengths for 3 of the 4 HMPOs.

The results are shown in Table 1, with comparisons of the fluxes to those of the MSX and IRAS PSC.

IRAS 22151+5912 is typical of the 3 compact sources. Figures 1-4 compare its continuum emission at 1.2 mm (IRAM), a low resolution 21.3 □m MSX image , a high resolution 20.9 □m IRTF image (our data), and a 2.2 □m 2MASS image, respectively.

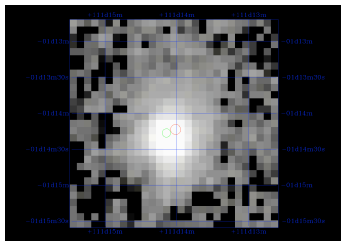

Fig. 2. 21.3 □m MSX image of IRAS 23151+5912 made with 18.3" resolution. The field of view is 3'. The MSX point source position is shown with the green circle, and the IRAS PSC position with the red circle. This map is in galactic coordinates.

DISCUSSION

Three of four sources are quite compact--essentially unresolved or marginally resolved on the IRTF with MIRSI.

Each compact MIRSI mid-IR source is probably due to hot dust surrounding a single, isolated high-mass protostellar object.

Each of these HMPO candidates has its MSX:IRAS 10 □m flux ratio between 60 and 100%, with 3 of the 4 near 100%

Each has its MSX:IRAS 20 □m flux ratio between 60 and 75%.

Each of the three MIRSI sources detected at both wavelengths has its MIRSI:MSX 10 □m flux ratio between 40 and 60%

Each of the three MIRSI sources detected at both wavelengths has its MIRSI:MSX 20 □m flux ratio between 50 and 90%

A major fraction of the mid-IR emission of 3 of 4 sources is concentrated in the compact MIRSI source.

DISCUSSION (Cont'd)

Models for the mid-IR-mm dust emission of star forming cloud cores should account for the very different spatial scales at different wavelengths.

A significant fraction of mid-IR emission in each of these high-mass star forming regions is probably due to dust around an individual high-mass protostar.

Comparison of 2MASS images at J and K$_s$ suggest the presence of obscured clusters associated with the mid-IR sources.

Acknowledgements
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REFERENCES

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Table 1. MIRSI, MSX and IRAS Data

Source	IRAS 22134+5834		IRAS 22570+5912		IRAS 23033+5951		IRAS 23151+5912	
Band	10 □m	20□m	10□m	20□m	10□m	20□m	10□m	20□m
MIRSI $F_{□}$ Jy	4.9[1]	121[2]	0.9[1]	---[2]	3.5[1]	19[2]	21[3]	65[2]
MIRSI FWHM "[4,5]	2.4"	2.2"	1.6"	---	1.2"	1.7"	1.3"	1.7"
MSX $F_{□}$ Jy[6,7]	13	135	11	75	6	31	49	126
IRAS PSC $F_{□}$ Jy[8,9]	14	178	17	135	6	48	50	203

Notes:
[1] N band 10.4 □m, 47 % bandwidth
[2] 20.9 □m, 42 % bandwidth
[3] 11.6 □m, 10 % bandwidth
[4] 10 □m Beam FWHM =1.2"
[5] 20□m Beam FWHM =1.6"
[6] MSX Band C, 12.1 □m
[7] MSX Band E, 21.3 □m
[8] IRAS 12 □m
[9] IRAS 25 □m

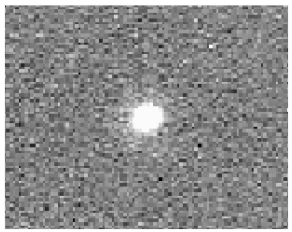

Fig. 3. 20.9 □m IRTF-MIRSI image of IRAS 23151+5912 made with 1.6" resolution. The source has 1.7" FWHM--virtually unresolved. The precise position of the source has yet not been determined. The field of view of this image is 24".

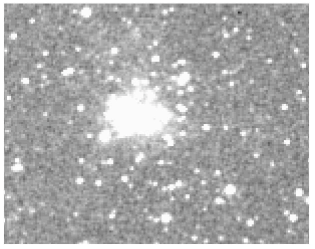

Fig. 4. 2.2 □m K$_s$ 2MASS Quicklook Image from the IPAC website. The IRAS 23151+5912 position is at the west (right) end of the overexposed region. The field of view of this image is about 4'. The 2MASS images suggest the presence of an obscured cluster.

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