Getting more than a GLIMPSE - Outflows from massive YSOs

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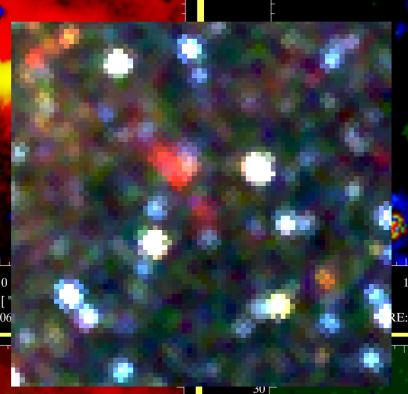
Abstract: The sensitivity, wavelength range, and spatial resolution of *Spitzer*-IRAC permits the detection of emission from shocked gas caused by outflows from the youngest massive protostars. We identified numerous candidate flows in the GLIMPSE survey by their excess emission in continuum-subtracted 4.5µm images. The sample comprises about 90 targets which are both luminous and extremely young as indicated by their frequent association with 6.7GHz methanol masers. Follow-up narrow-band imaging with NTT SOFI will prove whether the excess emission indeed arises from shocked molecular hydrogen or not. The verification of the presence of bipolar outflows will substantially increase the number of massive YSOs for which unanimous evidence of disk accretion exists.

Introduction: There is observational support that stellar growth via accretion can produce final stellar masses of up to 8. . .10$M_\odot$ [1]. The fact that no evidence for disks and jets was gained for higher stellar masses yet and no undisputed signs for the build-up of massive stars by coalescence were found so far [2] represents a serious challenge which has to be tackled. The *Spitzer*-GLIMPSE survey provides an excellent starting point to detect extremely young massive stars because of its unprecedented sensitivity, wavelength coverage, and spatial resolution [3]. The IRAC bands cover a multitude of lines, in particular from H_2, which are excited in shocks caused by jets and bipolar outflows [4]. The H2(0-0) S(8) to S(11) lines around 4.5µm can be rather bright at intermediate excitation temperatures as well as the [FeII] 4.89µm line at higher temperatures. This allows us to search for candidate outflows from massive YSOs in the GLIMPSE images. This poster summarizes the current status of this project.

Method: The 5.8, 4.5, and 3.6µm IRAC images were combined into RGB frames for visual inspection. In order to enhance the contrast, the underlying continuum was fitted by a power law (using channels 1,3, and 4) and subtracted. Candidate objects were identified by their excess emission at 4.5µm. 89 objects were found which represent our sample. Furthermore, the power-law fits yielded color temperature maps which will be used in our further study (see Fig.1). The continuum-subtracted images not only revealed compact H_2 emission but also the widespread fluorescent surface glow of molecular clouds caused by the interstellar UV field.

Fig.2 RGB image of G333.46-0.16 based on 2MASS frames. The 4.5µm excess is associated with diffuse Ks emission.



Results: Plots of all but one sources are displayed on this poster (FOV 1.3'x1.3'). The contour lines delineate the MIPS 24µm emission for those objects with MIPSGAL coverage. While the major fraction of the sample comprises known massive star-forming regions, a substantial part represents hitherto unstudied sources. 32 objects do not have an IRAS point source within 1'. For about half of the sample there is no association with an MSX source (within 15"). Using the same radius for searching SIMBAD entries resulted in 34 non-identifications. The available MIPSGAL data shows that most of the sources have strong 24µm counterparts, indicative of luminous, deeply embedded objects.

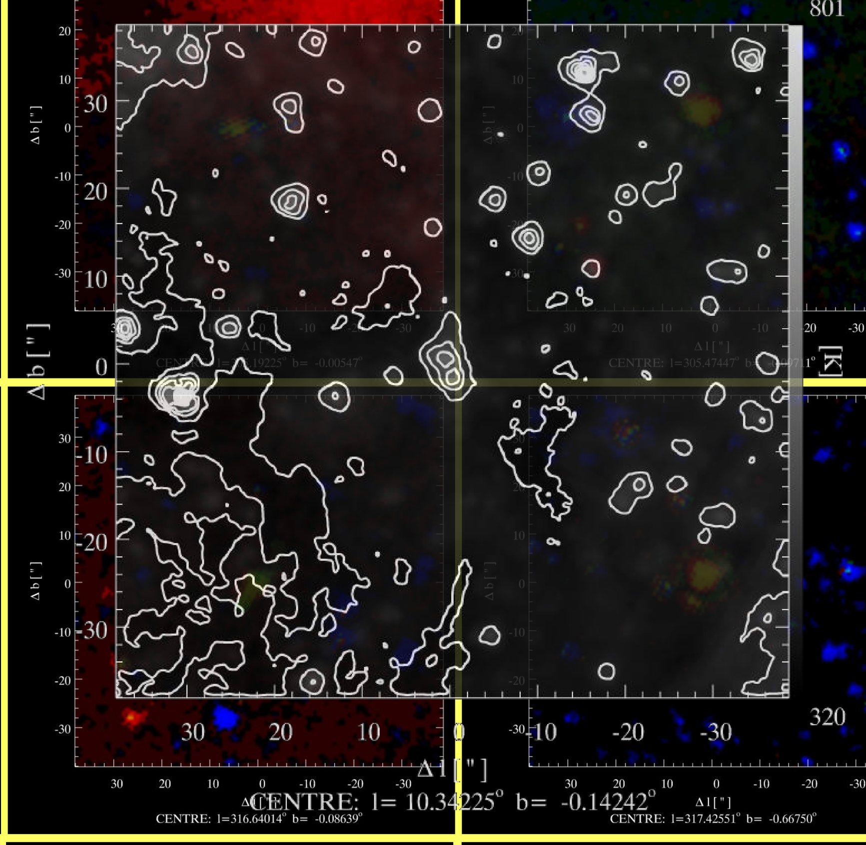


Fig.1 Color temperature map of G10.34-0.14 (contour spacing 50K). The average color temperature of the region associated with the H_2 emission is ~480K.

Discussion: A compact 4.5µm excess source can be "faked" by the interplay of the wavelength dependence of the extinction curve and the spectral energy distribution of background stars [5]. Thus, narrow-band imaging is mandatory to confirm the H_2 emission. For this purpose time was granted by ESO for SOFI observations. Narrow-band imaging exists for a few sources of our sample and other similar objects observed with IRAC, e.g. DR21 [6, 7]. It confirms our conclusions drawn from the *SPITZER* data. Known molecular outflows can be traced by the associated H_2 emission seen in the IRAC images, e.g. in the case of G343.12-0.06 [8]. Most of the objects have very red counterparts in 2MASS (see Fig.2). The different appearance of the 4.5µm and 2.16µm emission points to extinction as well as excitation variations. The bulk of the objects is associated with masers, in particular class II methanol masers, which are signposts of extremely young luminous objects [9]. This early temporal coincidence might not be by chance. The reduced optical depth in the cavities caused by powerful outflows allows photons to escape. Their absorption by dust causes grain heating. This in turn leads to the evaporation of grain mantles, transferring CH_3OH into the gas phase, and intense IR radiation due to thermal emission. These are prerequisites for pumping class II methanol masers [10].

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