Submillimeter Observations of the Star Formation Activities in the IRDC G049.40-00.01

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High-mass Star Formation

Massive stars are expected to be formed in molecular clouds with a large mass concentrated in a relatively small volume. Kauffmann & Pillai (2010) suggested a threshold for massive star formation by comparing clouds with and without massive star formation: $m_{KP} = 870 M_\odot r^{1.33}$, where $r$ is the effective radius in pc. Clouds/clumps more massive than this threshold seem to form massive stars.

All the clumps are distributed near $m_{KP}$, within a factor of ~3.5 (Figure 2.). Association with bright 24 µm point-like sources is an indicator of star formation because 24 µm emission traces warm dust heated by the material accreting onto a central protostar. Fourteen clumps out of 21 have 24 µm point-like sources within their extent. The most massive ones (clumps 3 and 16) even show extended, enhanced 4.5 µm emission called “green fuzzies” or extended green objects, which indicate shocked gas (Chambers et al. 2009). In the G049.40-00.01 region, two compact HII regions. Clumps 3, 16, and 20 (clumps associated with “green fuzzies” or compact HII region) are located well above $m_{KP}$, and this fact seems to corroborate the threshold for massive star formation suggested by Kauffmann & Pillai (2010).

We observed the IRDC G049.04-00.01 in the 350 and 850 µm continuum with the SHARC-II bolometer camera. The dark features in the infrared images have a good agreement with the emission structure in the submillimeter images. Twenty-one clumps were identified based on the 350 µm continuum map, and the mass of each clump ranges from 50 to 600 $M_\odot$. All the clumps are distributed near the threshold for massive star formation. The IRDC G049.04-00.01 contains objects in various evolutionary stages of star formation.

REFERENCES


Figure 2. Mass-size diagrams for the clumps detected in the 350 µm map. Clumps associated with 24 µm sources are marked by red circles. Two large green circles mark the “green fuzzies”. The solid line represents the mass-size threshold for massive star formation, $m_{KP}$, proposed by Kauffmann & Pillai (2010).

Figure 1. Infrared and submillimeter maps of the IRDC 049.40-00.01. (a) IRAC three-color composite (8.0 µm in red, 4.5 µm in green, and 3.6 µm in blue) image overlaid with the 4σ contour of the 350 µm map. Two large crosses mark the compact HII regions PR 29 and 30, from north to south (Phillips & Ramos-Larios 2008). (b) IRAC and MIPS two-color composite (8.0 µm in cyan and 24 µm in red) image. The scale bar indicates 2 pc. (c) SHARC-II 350 µm image (both gray scale and contours). The compact sources (clumps) are labeled and marked by small crosses. Contour levels are 4, 8, 12, 16, and 20 x 0.09 (1σ) Jy beam$^{-1}$. (d) SHARC-II 850 µm image. Contour levels are 3, 6, 9, and 12 x 0.05 (1σ) Jy beam$^{-1}$. The crosses mark the positions of the 350 µm clumps. The filled triangles mark the YSOs from Kang et al. (2009). The FWHM resolutions of the SHARC-II maps are indicated in the bottom left corners. The extraneous contours (noisy areas) near the edges of the SHARC-II maps should be ignored.