Near Infrared Extinction Cores in the Outer Galaxy

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Introduction: The current developments of new and promising instruments such as SCUBA2, Herschel and ALMA will allow us to better observe the physical and chemical conditions in regions of star formation in greater detail than ever before. We are especially interested in the earliest stages of high-mass star formation; how do these stars form and what are the properties of the newborn stars. Unlike low- and intermediate-mass stars, forming through gravitational collapse and subsequent accretion [1], the formation process of high-mass stars is still poorly understood. Mainly because of the fast formation process and the relatively rare occurrence of high-mass stars, the early stages are difficult to observe.

The current view is [2], that all massive stars form in clusters. The precursors of such clusters should be cold and contain significant mass to produce several high-mass stars in addition to a large number of low-mass stars. Infrared Dark Clouds (IRDCs), being cold and massive condensations in larger molecular complexes seem to be the ideal candidates. The recent discovery of the IRDCs in the mid-90's by the ISO [3] and MSX [4] satellites finally opened the door for observing and modeling the earliest stages of high-mass star formation.

Indeed it has recently been established that IRDCs are closely related to high-mass star formation. Not only are some IRDCs physically interacting with star forming activity [5], but several cases are known now where models suggest the presence of one or more high mass proto-stellar objects [6,7].

Current Work: Due to observational bias, IRDCs have only been detected towards the bright mid-IR Galactic Plane in the 1st and 4th Galactic quadrant, where they are seen as dark silhouettes. In our effort to understand the nature and structure of IRDCs and their dependence on Galactic environment we are searching for similar objects in the Outer Galaxy where the environment is much different. To identify Outer Galaxy IRDC candidates we use the 2 Micron All Sky Survey Point Source Catalog (2MASS PSC) to create extinction maps of the region ranging from l = 90 to 270 degrees and b = - 4 to + 4 degrees. The extinction is calculated, on a rectilinear grid with cell-size 30 arcseconds, from the average infrared color excess of stars in each cell and from the stellar density [8]. We then identify the regions where the visual extinction is three or more magnitudes higher than the local background and call these condensations. Our catalog of candidate IRDCs consists of; a) all cores in condensations that have visual extinction, derived from color excess, higher than 5 magnitudes, b) all cores that have visual extinction, derived from star counts, 2 sigma above the local background. In addition, for both definitions the minimal size of a core is 9 pixels. Both, or one of the two definitions can specify a core. A first paper [9] will introduce the catalog and describe the identification method in more detail. A subsequent paper [10] will analyze the sources in the catalog. Many candidates will have counterparts in e.g. MSX mid-IR emission and/or the IRAS point source catalog. The second paper will compare our results with existing surveys and catalogs.

This poster will introduce the catalog and show the extinction images produced for the Outer Galaxy.

Outer Galaxy IRDCs: The power of the method briefly described above will also be presented. We show the results of observations conducted with IRAM, the Effelsberg telescope and the JCMT of one candidate region in our pilot search. This region was identified as a condensation containing several cores, but lacking any significant mid-IR emission.

Figures: The first figure below shows the mid-IR emission from MSX in grey scales. On top of it the blue contours show the extinction derived from color excess (5-14 Av) and the red contours show the extinction derived from star counts (1.5-4 Av). The second figure shows the C18O (2-1) emission in the same region, observed with HERA on the IRAM 30 meter telescope. Note the filamentary structure of the complex, and the presence of several cores.

References: [1] Palla, F. and Stahler, S.W. (1993) ApJ, 418, 414 [2] de Wit, W.J. et al. (2005) A&A, 437, 247 [3] Perault et al. (1996) A&A, 315, L165 [4] Price et al. (1995) Space Science Reviews, 74, 81 [5] Redman, R.O. et al. (2003) ApJ, 586, 1127 [6] Ormel et al. (2005) A&A, 439, 613 [7] Rathborne et al. (2005) ApJL acc. [8] Lada, C.J. et al. (1994) ApJ, 429, 694 [9] Frieswijk et al. (2005A) in prep. [10] Frieswijk W.F.W. et al. (2005B) in prep.

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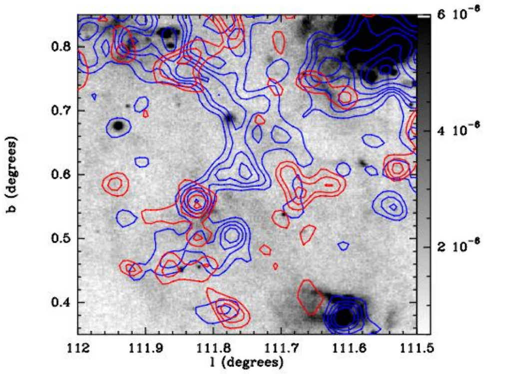

Figure 1: Extinction, see text for details

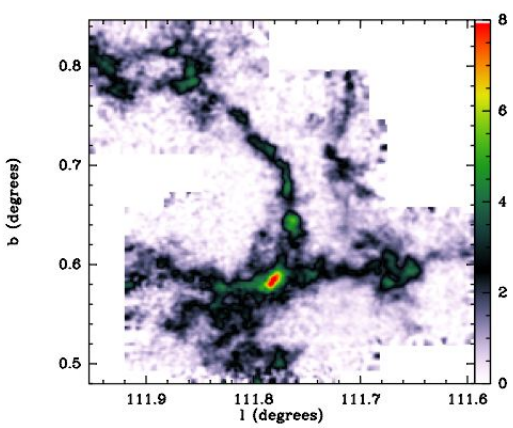

Figure 2: C18O (2-1), see text for details