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Star Formation at Dome C

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Abstract. I present a project relative to the star formation that will be developed at Dome C with the infrared telescope IRAIT equipped with the mid-IR camera TIRCAM2 during the first observing run that is planned for the period November 2005-February 2006.

Key words. Dark Clouds – Bok Globules – Young Stellar Objects

1. Introduction

The Dome C site at 3200 m s.l. on the Antarctic Plateau is one of the best place on Earth to observe the infrared region of the spectrum, given the exceptionally cold and dry conditions. For these reasons an Italian consortium composed by different institutes, proposed several years ago for Dome C the realization of a small size infrared telescope (IRAIT) (Busso et al. 2002). This telescope will be send in Antarctic within 2004. During the first operational phase (November 2005- February 2006), IRAIT will be equipped with the mid-IR camera TIRCAM2 operating at the Italian infrared telescope of the Gornergrat (TIRGO) (Persi et al. 2002). The mid-IR camera will be upgraded to match the characteristics of the telescope and of the Antarctica conditions. Star formation in our Galaxy represents one of the most exciting subjects of the modern Astronomy. As the star forms in very dense and cold clouds, the early evolutionary phases of a star can be observed at infrared, specially in the 3-20 μm spectral region. IRAIT equipped with TIRCAM2 will allow to obtained high sensitivity and moderately large field of view mid-IR images ($\sim$ 4'X4'). This unique opportunity will be exploited to make very deep and large field surveys of selected regions of the Galactic plane and of the Magellanic clouds. Three different key projets relative to star formation are proposed by the IRAIT consortium, including the study of the young stellar population in the giant molecular cloud NGC 6334; the discovery of new young brown dwarfs in the Chamaeleon dark clouds complex; and a mid-IR survey of small dark clouds with characteristics resembling Bok Globules. I'll present here the details of one of these key programmes relative to the small dark clouds.

2. Mid-IR survey of small Dark Clouds

Dark Clouds (DCs) represent regions of the sky in which the apparent surface density of

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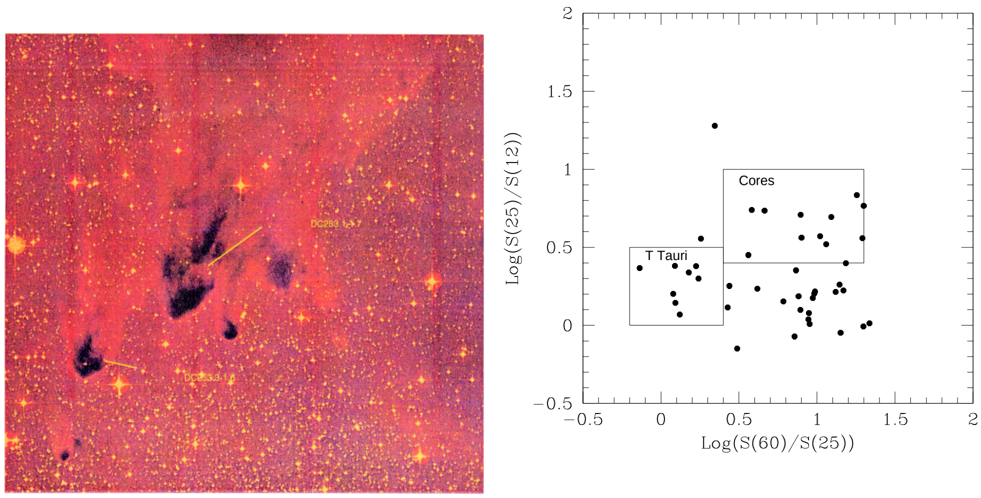

Fig. 1. Left panel: The Palomar Sky Survey red print around a complex of small dark clouds. Right panel:The distribution in the IRAS 12-25-60 μm color-color plot of the 55 selected DCs. In the plot are indicated the regions occupied by classical T Tauri stars and embedded sources.

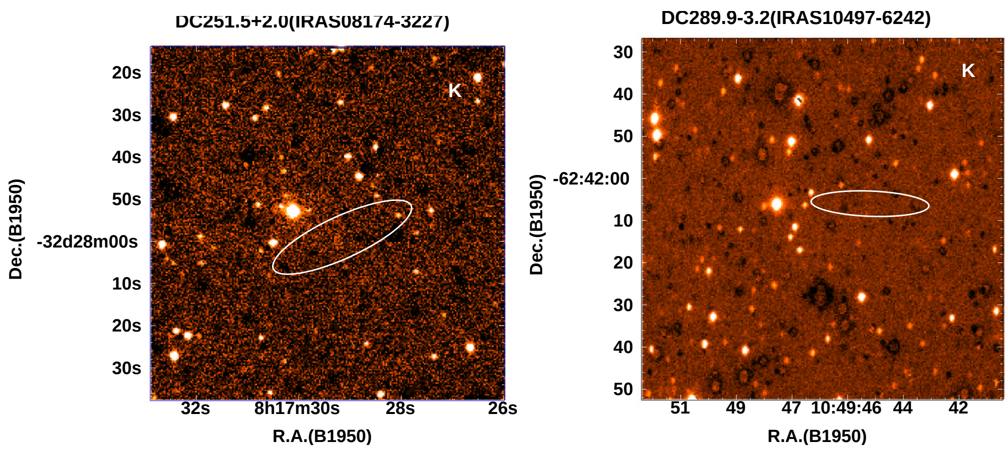

Fig. 2. Left panel:K-band image of IRAS08174-3227(DC251.5+2.0). Right panel:K-band image of IRAS10497-6242(DC289.9-3.2)

stars is reduced compared to surrounding environment. Figure 1 (left panel), shows as an example the optical image obtained from the Palomar Sky Survey (PSS) plates of a complex of very small dark clouds. Using the ESO/SERC Southern J survey plates, Hartley et al. (1986) reported a catalog of 1101 new southern DCs ($\delta \leq$ -33°). Approximately 16% of these DCs are associated with IRAS sources which characteristics are typical of embedded young stellar objects (YSOs). Studies of selected samples of these isolated small dark clouds have been undertaken at different wavelengths. From an ammonia survey, Bourke et al. (1995) derived the physical charac-

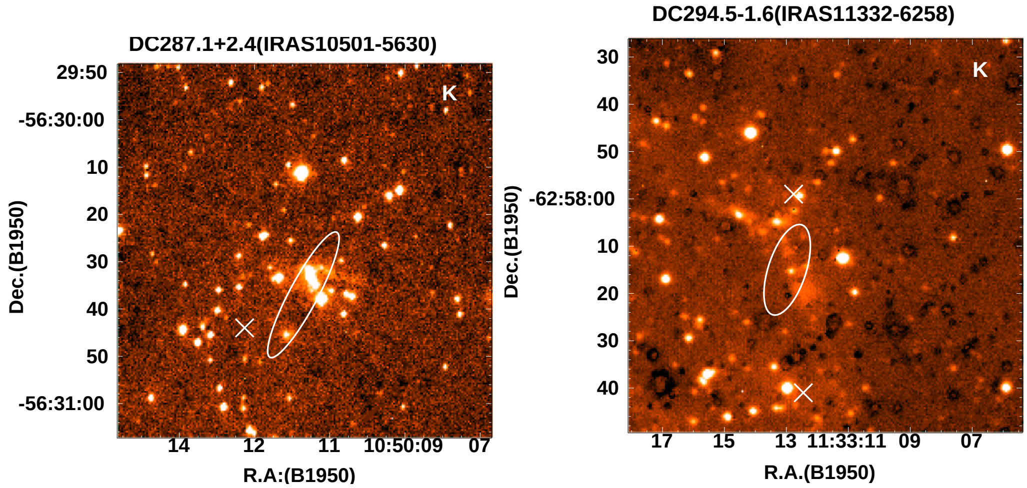

Fig. 3. Left panel:K-band image of IRAS10501-5630(DC287.1+2.4) Right panel:K-band image of IRAS11332-6258(DC294.5.9-1.6)

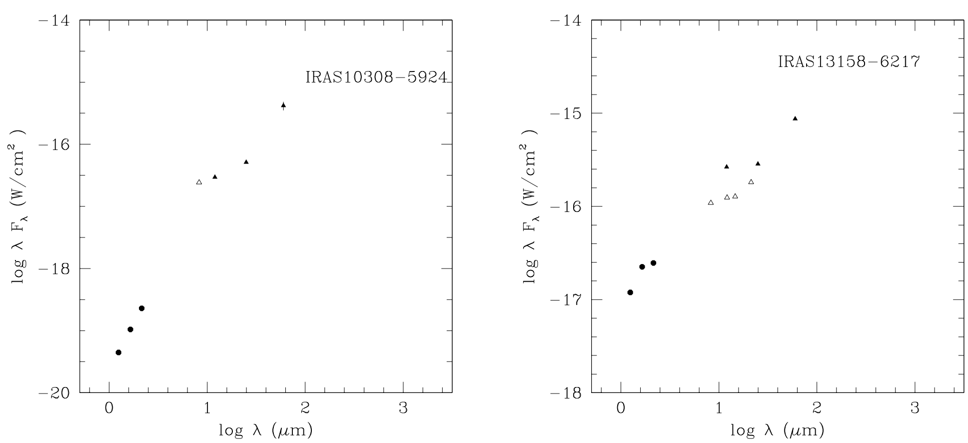

Fig. 4. Spectral energy distributions of two Class I sources in DC286.2-1.3(left panel), and in DC306.2+0.1(right panel)

teristics of a set of very small DCs indicated as "globules", while near-IR observations of southern DCs with the IRAS counterpart (Persi et al. 1990) (Santos et al. 1998), indicates that these "globules" are active site of isolated very low-mass star formation. Of the 35 "globules" observed at 1.3mm continuum (Henning & Launhard 1998), 18 where detected indicating that very young embedded objects are present in the small DCs. According to the model proposed by Lada (1987) for the evolution of low-mass stars,the very early phases often are not accessible from near-IR observations. Therefore, a systematic mid-IR imaging survey of these southern " globules" is important to identify and to study the very early phases of low-mass

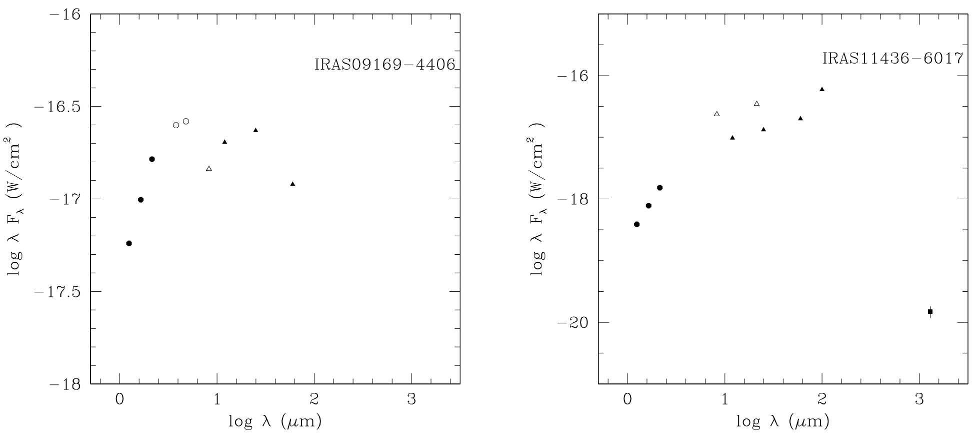

Fig. 5. Spectral energy distributions of two Class II sources in DC267.9+3.6(left panel), and in DC295.0+1.3(right panel))

star formation. A sample of 55 small southern DCs from the list of Hartley et al. (1986) with angular dimension less than 55 arcmin^2 and with IRAS counterpart has been selected to be imaged in the 10 and 20 μm with IRAIT/TIRCAM2. All these regions were previously observed with a photometer in JHKLM bands by Persi et al. (1990). The IRAS color-color diagram of the selected sources illustrated in Figure 1 (right panel), suggests that a population of classical T Tauri stars and very embedded YSOs are associated with the DCs. Several sources shows anomalous IRAS colors, indicating a contribution of more than one source at the IRAS flux. Most of these selected DCs have been imaged in JHK with the NICMOS3 near-IR camera on the 2.5m du Pont telescope at Las Campanas Observatory, and with the 2Mass survey. A group of the selected DCs does not show any near-IR sources within the IRAS positional uncertainty ellipse at a limit of K$\sim$17 mag. Figure 2 shows the K-band images taken at Las Campanas (Persi et al. 2003) of two of these sources. Particularly interesting appears DC289.9-3.2 in which has been detected the emission at 1.3 mm continuum (Henning & Launhard 1998). This results indicates the presence of a very deeply embedded low-mass protostar still in the accreting phase (probably a Class 0 source) in this DC. A second group of selected DCs is characterized by the presence of multiple sources associated with IR nebulosities inside the IRAS positional ellipse error, as reported in Figure 3. This represents a more complex case in which a multiple system of low-mass stars is forming in the region. Mid-IR images in this case are important to separate the different YSOs and to derive their spectral energy distribution(SED). The shape of the SED indicate a different evolutionary stages of low-mass YSOs (Lada 1987). Very steep SEDs (Figures 4) are associated with YSOs of age between 10^4 and 10^6 yr still accreting matter. The presence of an outflow and the formation of an optically thick disk characterizes this phase (CLASS I sources). Flatter SEDs indicates YSOs of ages between 1 and 100 Myr in which mostly of the mid-IR emission is due to the dusty disk surrounding the star (Class II sources)(Figure 5) Finally, the near-IR images of few selected DCs indicate the presence of embed-

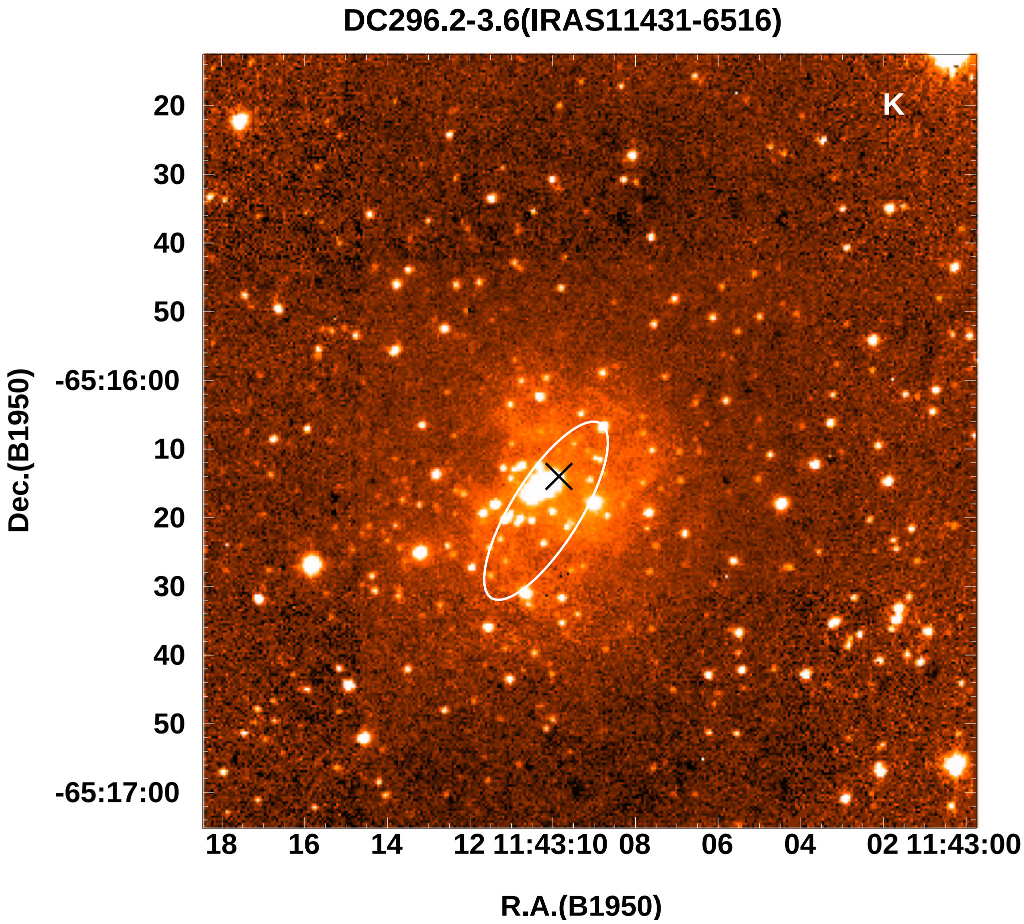

Fig. 6. K-band image of IRAS11431-6515 associated with the DC296.2-3.6.)

ded young stellar clusters as in the case of the DC296.2-3.6 illustrated in Figure 6. The estimate sensitivity of this limited survey will be of approximately 42mJy and 156mJy (S/N=3, t_{in}=5min on source) at the N and Q bands respectively for a point-like source. These values have been computed taking into account the characteristics of the TIRCAM2 array (128X128 Si:AS Hi-flux BiB), a scale of 2 arcsec/pix, the high transmission of the IR atmospheric windows at Dome C, the very cold temperature of the site that reduce the thermal background, and the collecting area of the IRAIT telescope. These limit are better than the IRAS survey and are comparable with those of the infrared MSX satellite (Egan et al. 1999) that operated at the same wavelengths. The advantage of the IRAIT/TIRCAM2 mid-IR survey is the better spatial resolution respect to the previous all sky mid-IR survey (IRAS) and the limited galactic plane survey obtained with MSX.

3. Conclusions

The exceptional dry and cold conditions of Dome C allow to make high sensitivity observations in the 10-20 μm spectral region even with a small size telescope. This high sensitivity joined with a moderately large field of view that can be obtained with the use of small size telescopes represents an unique opportunity to make very deep mid-IR surveys of selected regions of the sky.

The 80cm infrared telescope IRAIT that will be installed at Dome C at the end of 2004, equipped with the thermal camera TIRCAM2 will be used mainly to make deep and wide (4X4 arcmin^2) surveys at 10 and 20 μm of a selected number of targets. The infrared study of Galactic star formation represents one of these objectives of IRAIT/TIRCAM2. In particulary three key projects have been selected for the first period of observations. One of these projects is the 10-20 μm imaging survey of 55 southern small dark clouds with characteristics similar to Bok Globules, in order to identify the YSOs associated with the DCs and to derive their spectral energy distribution.

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