Far infrared observations of pre-protostellar sources in Lynds 183

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ISOPHOT far infrared observations of L 183

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Using ISOPHOT maps at 100 and 200 µm and raster scans at 100, 120, 150 and 200 µm we have detected four unresolved far-infrared sources in the high latitude molecular cloud L 183. Two of the sources are identified with 1.3 mm continuum sources found by Ward-Thompson et al. (wthompson94, wthompson00) and are located near the temperature (8.3 K) and masses (∼1.4 and 2.4 M⊙). They are found to have masses greater than or comparable to their virial masses and are thus expected to undergo gravitational collapse. We classify them as pre-protostellar sources.

The two new sources are good candidates for pre-protostellar sources or protostars within L 183. Stars: formation – ISM: clouds – dust, extinction – ISM: individual objects: Lynds 183 – ISM: individual objects: Lynds 134N – Infrared:ISM

Introduction

Low-mass stars are known to form within dark clouds. To study the initial conditions for their formation, it is important to probe the physical conditions of both molecular gas and cold dust in the deep interiors of such clouds. Dense cores have been identified inside dark clouds, some probably being in the stage of contraction to form a star. A pre-protostellar core is defined as the stage in which a gravitationally bound core has formed in a molecular cloud, but no central hydrostatic protostar exists yet within the core (see e.g. Ward-Thompson et al. wthompson94). Pre-protostellar cores are thought to be very cold. Thus, in many cases they escaped detection by IRAS, limited to λ ≤ 100 µm.

The long wavelength and multi-filter capabilities of ISOPHOT aboard the Infrared Space Observatory (ISO) (Kessler et al. kessler96), combined with its improved sensitivity and spatial resolution over IRAS, have been utilized in studying the far-IR emission of molecular clouds and pre-stellar and young embedded stellar objects within them. Analysis of their physical parameters is facilitated by using the spectral energy distributions (SEDs) obtained from ISOPHOT multi-filter photometry.

Lynds 183

The dark cloud/large globule L 183, frequently cited also as L 134 North, is a prototypical dense cold molecular cloud. Its visual extinction is estimated to be ~17′′ based on its 200 µm optical depth (Juvela et al. juvela02). So far there is no evidence for associated newly born stars such as T Tauri stars or IRAS point sources. However, Martin & Kun (martin kun) have found a bona fide T Tauri star and Hα emission line star near L 183. These two stars are located outside our maps. Given its short distance of ~110 pc (Franco Franco) L 183 provides a good spatial resolution with the ISO FIR beam size (ISOPHOT’s spatial resolution of 45 at 100 µm corresponds to 0.02 pc at the distance of L 183). The location at high Galactic latitude (b = 36 deg) minimizes contamination with unrelated cirrus along the line of sight. The location of the Galactic plane at z = 65 pc imposes that the impinging ultraviolet radiation field is strongly asymmetrical.

A Digitized Sky Survey The Digitized Sky Survey was produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166. The images of these surveys are based on photographic data obtained using the Oschin Schmidt Telescope on Palomar Mountain and the UK Schmidt Telescope. The plates were processed into the present compressed digital form with the permission of these institutionised plate (‘Equatorial Red’ survey (UK Schmidt) IIIaF + RG610) image of L 183 is shown in Fig. optIR. In
The cloud has a dark core - bright rim structure, which is characteristic of clouds having high optical depth at visual wavelengths that are illuminated by the diffuse interstellar radiation field (Mattila mattila74; FitzGerald et al. fitzgerald76). The bright rim maximum occurs at a radius corresponding to extinction $A_\lambda \approx 1.5'' - 2''$.

Laureijs et al. (laureijs91) observed the 60 $\mu$m emission to decline relative to 100 $\mu$m emission in a narrow transition layer around the cloud edge. They explained this behaviour by assuming a separate grain component at 60 $\mu$m that undergoes a modification of properties in a transition layer.

Laureijs et al. (laureijs95) have used IRAS images, CO molecular line observations and blue extinction values from star counts for a large-scale study of the L 134 cloud complex, including L 134, L 169 and L 183. Using $^{13}$CO observations, they found 18 clumps in the complex and derived their properties. The clumps follow clear size vs. linewidth and luminosity vs. size relationships. An analysis and discussion of the dust and molecular gas properties in L 183 based on the ISOPHOT 100 and 200 $\mu$m emission maps has recently been presented by Juvela et al. (juvela02).

L 183 has been a favourite target for molecular line observations which have revealed it as a rich source of molecular species (see e.g. Swade swade89a, swade89b; Dickens et al. dickens). Lee et al. (lee01) have classified L 183 as a strong infall candidate. The optically thick CS($J=2-1$) lines in the inner region of the cloud show a double peak with the blue component brighter than the red one, which is characteristic of inward motions. Similar profiles suggesting infall motions have been observed for HCO$^+$(J=3–2) (Gregersen & Evans gregersen00) and for CS($J=2–1$) by Snell et al. (snell82).

Mapping of the millimetre and submillimetre continuum dust emission by Ward-Thompson et al. (wthompson94, wthompson99) has revealed a small extended core in the center of L 183. This source has been detected at 800, 1100 and 1300 $\mu$m, and has FWHM dimensions of $60 \times 40 (0.032 \times 0.021 \text{ pc})$ at 800 $\mu$m. According to Ward-Thompson et al. (wthompson94), the core is probably pre-protostellar in nature, i.e. at an earlier stage than an accreting Class 0 protostar (for the definition of a Class 0 object see André et al. andre93). The submillimetre emission from the core is consistent with the dust being heated externally by the general interstellar radiation field. Recent observations by Ward-Thompson et al. (wthompson00) have revealed that the continuum emission extends further to the south, and that there is another emission maximum located at a position about 1.5 south of the previously detected maximum, with a FWHM size of $120 \times 60$. From sub-mm polarization observations Ward-Thompson et al. (wthompson00) measured a magnetic field direction which is at an angle of $34 \pm 6$ to the minor axis of the core, and found evidence for decreasing polarization at the highest continuum emission intensities.

Ward-Thompson et al. (wthompson02a) have mapped the core of L 183 at 90, 170 and 200 $\mu$m with ISOPHOT. The core was not detected at 90 $\mu$m wavelength. The dust temperature derived from 170 and 200 $\mu$m data showed no temperature gradient across the core.

In this study, we search for pre- and protostellar objects in the cloud. Our maps are much bigger than previous (sub)millimetre continuum maps. The derived fluxes of the sources between 120–200 $\mu$m, located near the peak or in the Wien regime of the assumed blackbody radiation, are essential for temperature and thus mass determination of the objects. Only if the masses of the objects are determined can we study their dynamical state. Furthermore, we study the relation of young (proto)stellar objects with the properties of the underlying dust in the cloud such as temperature and column density.

In the context of L 183, the term ‘pre-protostellar core’ has been previously used to refer to the two known (sub)mm continuum sources within the cloud (Ward-Thompson et al. wthompson94, wthompson99), and also to the cloud core itself in which these sources are embedded (Ward-Thompson et al. wthompson02a). Throughout this article, we use the term ‘source’ to refer to objects in L 183 which are unresolved in our maps, such as the previously-known continuum sources. By the term ‘core’, we refer to the visually opaque cloud core which is larger than the sources within it and resolved by ISO observations.

Observations and data reduction

figure Optical red Digitized Sky Survey (DSS) (a,b), 200 $\mu$m (c) and 100 $\mu$m (d) images of L 183. The four unresolved sources are marked as blue dots; for identification see Fig. cmaps. a) Digitized Sky Survey red plate. The image is scaled to best show the opaque core of the cloud. b) Digitized Sky Survey red plate. The image is scaled to best show details of faint surface brightness. c) False-colour image of 200 $\mu$m surface brightness. The colour scale is in units of MJy sr$^{-1}$. d) False-colour image of 100 $\mu$m surface brightness.
Zodiacal light of 4.0 $MJy \, sr^{-1}$ has been subtracted. The colour scale is in units of $MJy \, sr^{-1} \, \text{optIR}$.