Near IR imaging of dark globules as a tool to investigate their internal structure

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Little is still understood about the internal structure of dark cloud. This is largely due to the fact that these objects are composed almost entirely of molecular hydrogen, which is inaccessible to direct observation. Consequently, the usual methods used to derive the physical properties of the molecular clouds consist in the use of other tracers as the molecular species CO, CS, and NH\textsubscript{3} \cite{2}. However there is another way to determine the physical structure of a cloud and to trace its mass. Lada et al. (1994) demonstrated that the near-infrared imaging surveys of dark clouds can directly trace the distribution of dust extinction through a molecular cloud at higher angular resolution and greater optical depth than pure star counts.

We applied the NICE (Near Infrared Color Excess) method of Lada et al. (1994) at the southern dark globule CB 107 \cite{1}, located near the Galactic plane ($l = 2^\circ.8528$, $b = -2^\circ.7538$). The images at the photometric bands ($J=1.247\,\mu m$, $H=1.653\,\mu m$, $K=2.162\,\mu m$) are obtained, with the dithering techniques, at the ESO-NTT telescope with the SOFI camera. The raw observational data were reduced, registered, and combined in mosaics. Sources were identified and their photometry was obtained using the DAOPHOT package \cite{7} and photometric calibration was accomplished using the list of Persson et al. (1998) standard stars.

To determined the extinction map we scanned the image with a square spatial filter of 25\" in size and sampled at the Nyquist frequency. The result is a map of the infrared
color excess through the cloud; since the infrared color excess is proportional to the dust column density [6] the color excess map is equivalent to a extinction map (Fig. 1).

The values of the extinction $A_V$ and the dispersion $\sigma_{disp}$ on the boxes can be used to derive information on the structure of a cloud. Like for the molecular cloud IC 5146 ([3] and L 977 [4]) we find, for the globule CB 107, that $\sigma_{disp}$ increase in a systematic fascion with increasing of $A_V$. The trend is well fitted by the linear relation:

$$\sigma_{disp} = (2.18 \pm 0.02) + (0.21 \pm 0.01)A_V$$

(1)

As was shown by Lada et al. (1994), this indicates that, on scale smaller than resolution used for investigate the cloud, must be present significant structure. Padoan et al. (1997) found that random supersonic flows are excellent candidates for interpretation of the form of the observed $\sigma_{disp}$ versus $A_V$ relation.

To caracterize the structure of interstellar clouds we applied the concept of fractal curves to the contours of the extinction maps, estimating, in this way, their fractal dimension. To do this we used three relevant relations:

- perimeter-ruler relation;
- perimeter-area relation;
- $\Delta$ variance method.

The perimeter-ruler relation was originally developed for measuring the length of the coastlines. Using a ruler of length $l$, the length $L(l)$ is proportional to $l^{(1-D)}$, where
$D$ is the fractal dimension of the curve. We applied this relation at the iso-contour of the extinction map finding $\sim 2.2$ as fractal dimension of the cloud.

The perimeter-area relation use the values of perimeter $P_i(l)$ and area $A_i(l)$ computed for closed contour $i$; we can see that these are related by the relation: $P_i(l) = \rho A_i(l)^{(D-1)/2}$; where $\rho$ is a constant called prefactor, $l$ is the length of the ruler used, and $D$ is the fractal dimension. The application of this relation at the closed contour levels of the our extinction map allows us to find a fractal dimension $D \approx 2.2$ for CB 107.

The $\Delta$ variance method proposed by Stutzky et al. (1998) adopts an appropriate filter function $f(s)$, a wavelet, to convolve the image of the cloud. Using different values of the spatial scale $s$ the results obtained can be used to investigate the power spectrum of the image, and then, the fractal dimension. $D$ found by this method is $\sim 2.6$, greater than the value found by the other two methods.

References