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Velocity field structure in the Orion nebula

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Abstract. High quality interferograms have been obtained on the H II region in the Orion nebula in the emission line of [OIII] 5007 Å using the high resolution imaging Fabry-Perot spectrometer. Velocity profiles were obtained for about 2000 spatial positions. Two velocity components, a narrow one with FWHM of around 20 ± 3 km/sec and a broad one with FWHM of around 50 ± 3 km/sec are predominantly present in the profiles across the nebula.

Key words : Orion nebula—velocity field structure

1. Introduction

The Orion nebula (M 42, NGC 1976) is the closest H II region located at a distance of 460 pc, embedded with the multiple OB star complexes, θ^1 Ori (trapezium) and θ^2 Ori, and presents a good opportunity to study the physical processes taking place in the H II regions. In the past, several studies have been made to determine the radial velocity structure in the Orion Nebula (Wilson *et al.* 1959; Meaburn 1971; Goudis *et al.* 1983; Castaneda 1988) which showed the width of the spectral lines to be in excess of the thermal broadening and the presence of 'turbulence' was suggested. Several models have been constructed to explain the observations on general flow pattern : Blister model (Zuckerman 1973), the Champagne model (Tenorio-Tagle 1982), and the Stellar wind bubble model (Pankonin *et al.* 1979). The observations were, however restricted either to the bright portions (surrounding θ^1 Ori or θ^2 Ori) of the nebula or were concentrated on fine-scale structures like knots, jets and discovery of Herbig-Haro objects.

2. Observations

With the aim to sample larger regions without overly sacrificing on the spatial and spectral resolution, our observations on Orion were made by a newly constructed Imaging Fabry-Perot spectrometer (IFPS) using Imaging Photon Counting (IPD) detector (Seema *et al.* 1992) covering a wide field of view. Our observations covered the Orion bar, the dark bay and the molecular cloud regions of the Orion nebula allowing us to construct a comprehensive picture of the global velocity structure across the nebula. In view of the recent observations of extinction maps (Pogge *et al.* 1992) and infrared maps (Stacey *et al.* 1989) of the Orion nebula, our study becomes more significant as a comparative analysis is now possible.

Observations were made on a 35 cm celestron-14 telescope (*f*/11 Cassegrain) at Gurushikhar, Mt. Abu. By scanning the etalon in wavelength, thirty three interferograms were obtained in the emission line of [OIII] 5007 Å covering 10.5 arcmin. The spectral resolution was 7 km/sec and the spatial resolution was 4 arcsec (figure 1 shows a mosaic of four interferograms at four different etalon gap settings). Velocity profiles were obtained for about 2000 spatial

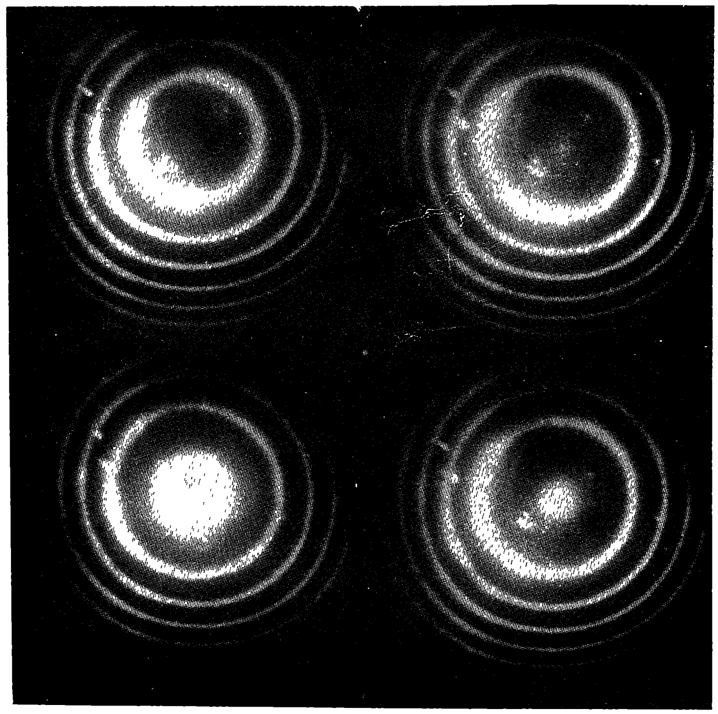

Figure 1. A mosaic of four interferograms of the Orion nebula in the [OIII] 5007 Å line taken at increasing and different etalon plate spacings with 5 min integration each (from Seema *et al* 1992).

positions. The profiles were highly asymmetric and therefore a single gaussian could not be fitted to the nebular profiles. Two velocity components (i) a narrow one with FWHM of around 20 ± 3 km/sec, and (ii) a broad one with FWHM of around 50 ± 3 km/sec are predominantly present in the profiles across the nebula. Iso-velocity contour maps are plotted for both the components.

3. Results and discussion

The important results of the analysis are as follows :

I. The general flow of relative radial velocities is found to be blue shifted with respect to the centre in agreement with the champagne model.

II. Certain high velocity flows are found across the nebula.

(i) *Around the trapezium stars* : Maxima around the trapezium stars could be caused due to the stellar 'bubble' formed by the strong stellar winds from θ^1 C Ori.

(ii) *1.2 arcmin north of trapezium stars* : This position corresponds to the strong infrared source at 2 μm of shocked H_2 peak (Beckwith *et al.* 1978). It is interpreted to be due to a cataclysmic event such as a supernova explosion.

(iii) *Near θ^2 B Ori* : High velocity flows found near θ^2 B Ori could be due to the stellar winds caused by the radiation pressure from the star.

III. *Orion bar* : Two arcmin south-east of trapezium stars corresponds to the bar ionization front in the Orion nebula. It is shown that bar represents the ionization front region formed at the HI-HII interface of the nebula. We have obtained for the first time, a velocity profile across the bar by taking a radial scan perpendicular to the bar, shown in figure 2. There is a sharp rise in velocity of about 20 km/sec at the bar position. The velocity from the direction of θ^1 C Ori increases to about 55 km/sec across the bar and then falls to about 35 km/sec outwards. A comparison of the velocity profile with the density profile (Pogge *et al.* 1992) shows that when the density is high (3200 cm^{-3}) velocity is relatively low (~ 45 km/sec) and when velocity is high (~ 55 km/sec) density is low (2000 cm^{-3}) in accordance with Rankine-Hugoniot conditions in flows across isothermal shock fronts (e.g., Lang 1978).

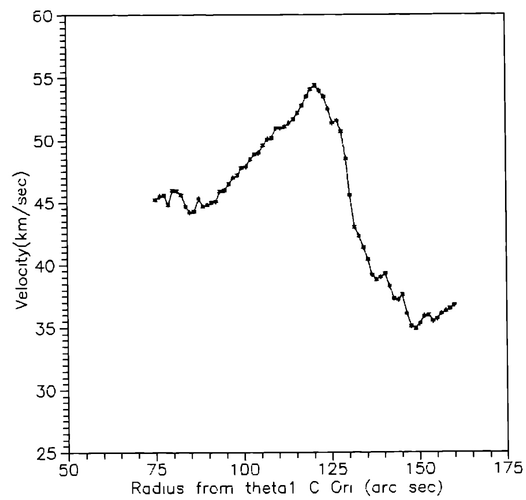

Figure 2. Radial scan perpendicular to the 'bar' ionization front.

IV. *Statistical analysis* : In order to study the random components, attributed to the presence of turbulent motions in the flow, we have made a statistical analysis from the large number of data points. These observations indicate that the 'turbulence' in Orion does not follow Kolmogorov's prescription due perhaps to the compressibility as well as to the possible presence of velocity variations along the line of sight.

4. References

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