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H_2 VELOCITY MAPS OF ORION: DESTRUCTION OF THE ENVIRONMENT OF THE BN-KL NEBULA[1]

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RESUMEN

Presentamos la estructura en velocidad de la emisión de H_2 a 2.12 μm en Orion, obtenida con un interferómetro IR Fabry-Perot con resolución espectral de 24 km/s y 2$''$ de resolución espacial, de una región de 3.6$'$×3.6' (0.46×0.46 pc^2) que contiene los dedos filamentarios de H_2. Se propone un modelo sencillo para explicar la estructura de baja velocidad descrita por sus momentos radiales: intensidad, centroide de velocidad, dispersión de velocidad y asimetría. Suponemos que el fuerte viento de 230 km/s producido por IRc2 interactúa con un conjunto de canicas moleculares con densidad de 5.6×10^5 cm^{-3}. Este escenario reproduce muy bien los momentos observados, provee pistas para la formación de los filamentos y la confinación del material molecular, y permite asociar la estructura azul de alta velocidad a la región. La emisión de H_2 es producida por un choque lento tipo-J (20 km/s) en las canicas moleculares con una emisividad proporcional a $v^{1.8}$. Estimaciones de la masa total del viento y masa de las canicas dan 0.5 $M_\odot$ y 15 $M_\odot$ dentro de un radio de 1$'$ (0.1 pc). Cada canica tiene masa y tamaño de $\times 10^{-3}$ $M_\odot$ and 0.007 pc, respectivamente. Concluimos que en una escala de tiempo de 2000 años la región central de 0.1 pc que rodea a la nebulosa BN-KL está en el proceso de ser destruida por el potente viento de IRc2.

ABSTRACT

We present the velocity structure of the 2.12 μm H_2 emission in Orion, obtained with an IR Fabry-Perot interferometer with a spectral resolution of 24 km/s and a 2$''$ spatial resolution, covering a region of 3.6$'$×3.6' (0.46×0.46 pc^2) that contains the H_2 filamentary finger system. A simple model is proposed to explain the observed low velocity structure as described by its radial moments: intensity, velocity centroid, velocity dispersion and skewness. We assume a strong wind of 230 km/s produced by IRc2 interacting with a set of molecular clumps with density of 5.6×10^5 cm^{-3}. The scenario provides a good match to the observed moments is obtained, gives clues to the development of filaments or fingers and entrainment of the molecular material, and associates the observed high velocity blueshifted emission to the region. The H_2 line emission is produced by a slow J-shock (20 km/s) in the clumps with an emissivity proportional to $v^{1.8}$. Estimates for the total wind mass and clumps mass yield 0.5 $M_\odot$ and 15 $M_\odot$ inside a radius of 1$'$ (0.1 pc). The individual clumps have masses and sizes of few $\times 10^{-3}$ $M_\odot$ and 0.007 pc, respectively. We conclude that the central 0.1 pc region surrounding the BN-KL nebula in front of OMC-1 is in the process of being disrupted by the strong wind of IRc2 on a time scale of 2000 yr.

Key Words: **ISM: MOLECULAR HYDROGEN, SHOCKS — NEBULAE: ORION K-L — STARS: MASS LOSS**

[1]Based on observations obtained at the Observatorio Astronómico Nacional at San Pedro Mártir, Baja California, México.

1. OMC-1 INFRARED SCANNING FABRY-PEROT OBSERVATIONS

CAMILA (Cruz-González et al. 1994) images were taken on January 19, 1997 under photometric conditions, with a FWHM of 2″, at the 2.1 m telescope of the OAN/SPM. The plate scale of 0.86 ″/pixel allowed coverage of a $3.67' \times 3.67'$ region centered on OMC-1, that corresponds to 0.46×0.46 pc^2 at the adopted distance of 430 pc. A set of images was obtained at 26 etalon positions (channels) that scan a single order at 9.82 km/s per channel with a spectral resolution of 24 km/s.

2. KINEMATICS OF THE MOLECULAR HYDROGEN GAS

The maximum of intensity occurs at 9 km/s, close to the rest velocity of OMC-1. We distinguish two components with different kinematics: the central region at low radial velocities ($-36 < V_{LSR} < 42$ km/s) with the finger system, and the central region at high blue shifted velocities. Details of the H_2 kinematics are presented in Salas et al. 1999.

3. THE BN-KL H_2 EXPANDING REGION

The geometry of the H_2 image moments strongly suggests a spherical symmetry for the velocity fields only broken by the ammonia walls (Wiseman & Ho 1996). We have averaged the observed moments of the intensity-velocity distribution: (a) 0th moment = continuum subtracted line intensity, (b) 1st moment = velocity centroid, (c) square root of 2nd moment, mathematically equivalent to the velocity dispersion, and (d) 3rd moment equal to velocity skewness; over the azimuthal angle to produce radial moments with the positions of IRc2 and BN as centers.

4. THE MODEL

In order to study the global low velocity distribution we have developed a model which assumes a two component ISM around the central source (IRc2). These components are a spherical low density and high velocity wind emanating from IRc2, and a collection of high density molecular clumps, probably the remnants of the protostellar cloud contraction, with a higher characteristic density. The developed model is presented in detail in Salas et al. 1999.

With this model we calculated the expected H_2 line profiles and, from them, the moments of the velocity distribution. The match with the observed moments is very good. No other model to our knowledge has reproduced the observed 1/r velocity field. Other decreasing velocity fields could provide similar results, but the proposed model has the advantage of maintaining a high constant velocity wind coexisting with the 1/r velocity field. The former could be responsible for HH objects observed at the tip of the fingers as well as the high velocity bullets, while the latter would be responsible for the bulk of the H_2 emission observed in the low velocity field.

Higher spatial resolution H_2observations should allow to study the internal shock inside individual clumps, in fact "nested arcs" in NICMOS observations published by Stolovy et al. 1998 seem to correspond to expected structures from J-shocks with an emissivity of $v^{1.8}$ that we derived.

We conclude that the central 0.1 pc region surrounding the BN-KL nebula in front of OMC-1 is in the process of being disrupted by the strong wind of IRc2 on a timescale of 2000 yr.

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