V645 Cyg - ON THE STRUCTURE OF A YSO

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ABSTRACT. In the CO(J=3-2) line we observe a bipolar outflow in V645 Cyg. The physical properties of the neutral flow gas and its geometry put new constraints on the structure of this YSO.

INTRODUCTION

V645 Cyg (AFGL2789) is one of the few young stellar objects (YSO's) which can be studied at many wavelengths. The visible object shows a star-like knot (N0) and a few nebulae filaments (N1,N2..). Its spectrum is like a Herbig-Ae star, with displaced absorption at velocities up to -340 km/s (LSR) and strong emission lines some of which show P-Cyg profiles; it rises steeply longward of 1 μm, H I IR emission lines and the 10 μm silicate absorption are observed. H_2O maser emission arises exactly from the position of N0. Radio continuum measurements gave only upper limits at 5 and 15 GHz. The distance of V645 Cyg, the nature of the central star, and the physical conditions in its environment have remained controversial. Associated with V645 Cyg is a molecular cloud (Harvey & Lada 1980). To investigate the distribution and kinematics of the molecular gas closely surrounding V645 Cyg, we performed CO(J=3-2) sub mm line observations. We briefly present here some main implications of our work (detailed discussion and figures in Schulz et al. 1987).

OBSERVATIONS

The map of 25 CO(J=3-2) spectra (2'x2'; 20" spacing, beam 26") was obtained during 17 - 24 April 1984 at the Multiple Mirror Telescope on Mt. Hopkins, Arizona, which was used as a phased sub mm array. The antenna temperatures are accurate to ± 10 %. The spectra show a line core component of gaussian shape at a velocity of -44.3 ± 0.1 km/s (LSR) and high-velocity wings ranging over ± 15 km/s and extending over an area of 1'x1' centered on V645 Cyg. Red-shifted and blue-shifted emission are spatially displaced by 20" at a position angle of $-25^{\circ} \pm 15^{\circ}$ which is about perpendicular to the optical polarization vectors of N0 and N1 (Cohen 1977).

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DISCUSSION

Derived properties of V645 Cyg depend on the distance. The kinematic distance is not reliable because of deviations from circular motions in the Perseus arm of our galaxy. Chavarria et al. (1986) have determined the distances of many H II regions in this area and related them to their velocities; from this analysis, at $l^{II} = 94.6^{o}$ and $v_{LSR} = -45$ km/s we obtain a distance of 3.0 ± 0.5 kpc for V645 Cyg which we adopt hereafter.

The visible spectrum indicates a strong wind, with no evidence for a hot O-type photosphere. The absence of noticeable radio continuum emission implies that the central star has not developed a photoionized nebula. In the (H-K)/(K-L) two-colour diagram V645 Cyg is located in the region of the extreme Herbig-Ae/Be stars (Goodrich 1986). The IR emission line spectrum (see McGregor et al. 1984) is similar to those of many other objects regarded as pre-main-sequence stars. All this gives evidence for V645 Cyg being a very young object. Its total luminosity is 4.5×10^4 $L_\odot$ (3 kpc dist.).

The 10 μm silicate absorption implies an A_V (star) of at least 10 mag towards the observer, much more than determined for NO and the other filaments. The optical spectra and the polarisation suggest that all visible features must be regarded as reflection nebulae and, according to very recent data by Goodrich (1986) and Solf (priv. comm.) have embedded knots of shock-ionized line emission.

The flow is only poorly collimated. From our CO(3-2) map, we can derive parameters for the outflow gas assuming 1.) thermalized CO emission, 2.) T_{ex} between 20 and 100 K, 3.) the outflow region being a cube of 1' on each side, 4.) CO abundance of 10^{-4}. Then, the total mass of the outflow gas is $\mathcal{M} = 7\mathcal{M}_\odot$; its mechanical luminosity ($3L_\odot$) is small; the corresponding momentum transfer rate, nevertheless, is close to the value derived for the stellar wind (Kwok 1981) using the expansion velocity of 330 km/s of Humphreys et al. (1980); hence, the ionized stellar wind may in fact be capable of driving the outflow and we do not have to assume an additional component to the wind.

We are not yet able to derive a unique model for V645 Cyg: The outflow seems to define a projected preferential axis; from the A_V values for the central star and for the nebulae, one finds an anisotropic dust distribution. But the variety of features with different high and low velocity components leave some confusion about the true geometry. Particularly, the fact that blue-shifted visual emission is located on top of red-shifted molecular gas still needs a comprehensive explanation.

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