They are new examples of infrared reflection nebulae like those found in Orion KL, Cep A, and S106. The polarization vectors show concentric patterns and the degree of the K band polarization exceeds 50% at some positions in the outer regions; scattering would be the mechanism of the polarization. The polarized flux was detected over the area of $\sim$ 1 arcmin from the central peaks with a limiting magnitude of $\sim$ 19 mag/square arcsec. At least some of the protostellar objects seem to have a stage in which they have such extensive reflection nebulae.

INTERACTION OF PROTOSTELLAR WINDS WITH THE ORION MOLECULAR CLOUD

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ABSTRACT. The effect of a strong protostellar wind on a dense molecular cloud with a magnetic field is investigated by time-dependent magnetohydrodynamic calculations which take into account the cooling due to H_2 molecules as the dominant one. The shocked region obtained here seems to be responsible for the formation of the bright H_2 emission with a high-velocity width observed in the Orion-KL Nebula.

1. ASSUMPTIONS AND METHOD

It is assumed that the mass loss rate of the wind from an inner boundary $r = r_*(0.003\ \text{pc})$ increases linearly with time until it attains a given mass loss rate and that thereafter both the mass loss rate $\dot{M}$ and the wind velocity u_* are constant there. The ambient molecular gas is initially assumed to exist wholly as H_2 molecules and to be at rest with uniform density n_0. We consider that only H_2 molecules are the dominant coolant, based on the analysis of the dissociation and radiative cooling by H_2 molecules developed by Lepp and Shull (1983). We consider the case where there is a uniform magnetic field in the ambient gas. The magnetic field has a component in the ϕ direction of spherical polars only, that is, $B = (0,0,B_0)$.

With spherical symmetry, the flow equations described by Lagrangian coordinates are numerically integrated by the implicit difference method. Table I shows the adopted model parameters which corresponds to those inferred for the bipolar source, Orion-KL (Chernoff *et al.* 1982).

2. RESULTS

The computations were continued until the outward facing shock arrives

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TABLE I. Adopted Model Parameters

Case	Mass Loss Rate $\dot{M}$ ($M_\odot$ yr^{-1})	Wind Velocity u_* (km s^{-1})	Ambient Density n_0 (cm^{-3})	Magnetic Field B_0 (gauss)
A	3×10^{-3}	70	2×10^5	5×10^{-3}
B	3×10^{3}	100	2×10^5	5×10^{-3}

at a distance of $\sim$ 0.07 pc, which corresponds to the distance of IRc2 to the H_2 emission Peak 1 in the Orion-KL if the bipolar flow is viewed nearly edge-on. The evolutionary times are $\sim$ 3500 and 2300 yr for cases A and B, respectively. The flow velocity, u, is almost constant in the unshocked wind region and is abruptly decelerated in the vicinity of the inward facing shock, thereafter u is gradually decelerated up to the position of the outward facing shock. This produces remarkable temperature rises in the inward and outward facing shocks, although the temperatures are considerably lower than the postshock temperature, $T_S \sim 1.6\times10^4 (v_S/20 \text{ km s}^{-1})^2$ K, expected from the non-magnetic shock velocity v_S.

The obtained shock velocities are $\sim$ 60 - 70 km s^{-1} in the inward shock and $\sim$10 - 20 km s^{-1} in the outward shock for cases A and B. The maximum temperatures are as high as $\sim 10^4$ K in the inward shock and $\sim 4\times10^3$ K in the outward shock. The resultant H_2 emission rates are considerably higher in the vicinity of these shocks than away from them though H_2 molecules are highly dissociative in the inward facing shock. The maximum H_2 emission rates amount to $\sim 10^{-12}$ - 10^{-10} and $\sim 10^{-13}$ erg s^{-1} cm^{-3} in the inward and outward shocks, respectively, for both cases. The width of the shocked region is comparable to the radius of the inner boundary ($r_* = 9\times10^{15}$ cm). The magnetic pressure is considerably enhanced in the shocked region. Accordingly, the shocked region was enlarged by the presence of a magnetic field, compared with the non-magnetic case.

We notice that the overall structure of the flow is wholly different from similarity solutions and other numerical calculations (Falle 1975, Weaver *et al.* 1977) for the stellar wind bubbles although present model parameters are very different from those used by them. The shocked temperatures in the inward facing shock are somewhat higher than the observed excitation temperatures $\sim 10^3$ - 4×10^3 K of the H_2 lines (Beckwith *et al.* 1978; Nadeau *et al.* 1982; Beck and Beckwith 1983). However, the present wind-cloud interaction models seem to be able to account for the H_2 and CO line emissions.

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EQUILIBRIUM AND COLLAPSE OF ROTATING ISOTHERMAL CLOUDS

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We have performed numerical calculations for both static and dynamic structures of molecular clouds in which stars would be formed. The assumption in our calculations is that a cloud, which is embedded in an external hot and tenuous uniform medium, is isothermal and axisymmetric.

According to our results, the equilibrium structures of rotating isothermal clouds have the following characteristic properties. A cloud cannot be stable but begins to collapse if the central density exceeds about 800 at most (in units of the density at the surface of a cloud, the sound speed in a cloud, and the gravitational constant). With an increase in the angular momentum J, the mass of a cloud M increases and the flatness becomes larger, but J/M^2 remains around 0.2.

When the angular momentum distribution is chosen to be the same as that of a rigidly rotating uniform sphere, we obtain the maximum mass ($M \sim 35$) for the sequences of stable clouds, where the flatness is about 16 and the cloud gives rise to ring-like fragmentation.

We have found through some numerical simulations together with analytic investigations that the structure of a collapsing cloud is closely similar to that of a cloud in equilibrium, which has a rigidly rotating uniform core, an inner envelope with the density profile $\rho \propto \varpi^{-2}$, and with the angular velocity profile $\omega \propto \varpi^{-1}$, where ϖ is the distance from the rotation axis, and an outer envelope subject to initial and outer boundary conditions.

This dynamic structure indicates that an axisymmetric isothermal cloud undergoes runaway collapse until the core becomes opaque, and that no hierarchical fragmentation occurs.

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