WIND PROPERTIES OF YOUNG STARS

Nino Panagia
Space Telescope Science Institute, Baltimore, USA

The statistical properties of winds form young stars are summarized and discussed. One and the same mechanism, possibly related to the process of star formation, appears to be responsible for mass loss in all pre-main-sequence stars. Moreover, evidence is found that the ionization and the acceleration of the winds of very young stars are produced by processes different from those operating in main sequence and more evolved stars.

A MECHANISM FOR VARIABILITY OF COMETARY NEBULAE

G.M. Rudnitskij
Sternberg Astronomical Institute, Moscow State University,
Moscow 119899, U.S.S.R.

A model is suggested to explain the variability of the optical structure and the integral brightness of cometary nebulae (CN) occurring at timescales of several years and tens of years (Gyulbudaghian *et al.* 1977, Cohen *et al.*1977, 1981, Magakyan 1981, Gyulbudaghian 1982). A CN is assumed to be a reflection nebula; it is a wall of a conical cavity in the circumstellar gas-and-dust torus illuminated by the central star (Cohen 1974). I explain the CN's variability by the presence of small tilted circumstellar disc of gas-and-dust, located inside the internal channel of the large circumstellar torus (see Figure 1). A similar model was put forward by Ward-Thompson *et al.* (1985) to account for a tilt angle of about 30° between the direction of short optical jets (stellar wind, channelled by the small disc) and the large-scale bipolar outflow (focused by the large torus) in the CN NGC 6729 associated with the star R CrA. Tilt angles of about 30° between optical and radio structures exist in CN NGC 2261 (Cantó *et al.* 1981) and GM 1-29 (Levreault 1984).

The small tilted disc will precess in the gravitational field with potential U of the large torus. Thereby the stellar light, emerging from the disc's poles, will illuminate consecutively, like a projector beam, different parts of the torus' internal wall, causing variability of the CN. The precession angular speed (Papaloizou and Pringle 1983) is given by

$$\Omega p = \frac{1}{2\Omega}\left(\frac{1}{r}\frac{\partial U}{\partial r} - \frac{\partial^2 U}{\partial z^2}\right)_{z=0},$$

where $\Omega = (GM_*/r_c^3)^{\frac{1}{2}}$. Approximating the torus of mass M_i by a homogeneous cylindrical layer (see Figure 1) with the external radius R_2, one can obtain for the case $r_c \ll R_1$:

$$\left(\frac{1}{r}\frac{\partial U}{\partial r} - \frac{\partial^2 U}{\partial z^2}\right)_{z=0} = \frac{3GM_i}{R_2^2 - R_1^2}$$

$$[(R_1^2 + H^2/4)^{-\frac{1}{2}} - (R_2^2 + H^2/4)^{-\frac{1}{2}}].$$

With $r_c = 10^{14}$ cm, $M_* = 3\ M_\odot$, $R_1 = H = 3\times10^{15}$ cm, $R_2 = 3\times10^{16}$ cm, and $M_i = 500\ M_\odot$ (Bally 1982, Ruzmaikina 1982), I obtain $T_p = 2\pi/\Omega_p = 43$ years. Thus, if the circumstellar torus is massive and compact, the precession will be rapid enough to account for the CN's variability.

The tilted disc was assumed to behave like a rigid body. This can be justified if the disc is viscous enough. Turbulent viscosity (Ruzmaikina 1982, Papaloizou and Pringle 1983) alone cannot provide the disc's resistance against the "smoothing" effect of the external force moment. However, there may be mechanisms of viscosity other than turbulence, which may increase the "smoothing" time considerably, e.g. magnetic effects (Uchida and Shibata 1984).

An observational test for this model would be the presence or absence of cyclic variations in the CN. Systematic data on long-term variability is lacking for most CN. It would be highly desirable to obtain such series of observations (as well as to study old plates), especially for those CN which show evidence for differing directions of optical and radio structures.

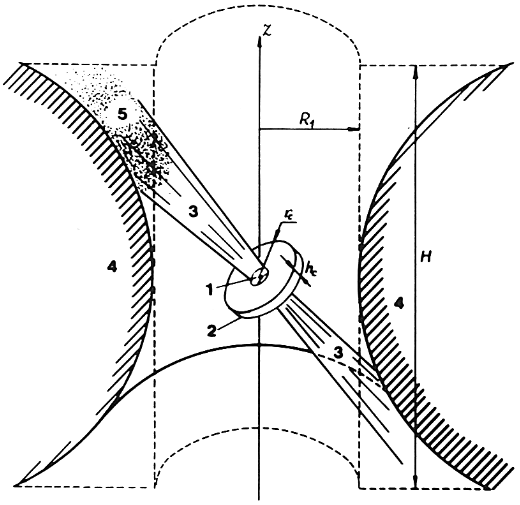

Fig. 1. The model: 1) the star, 2) the tilted disc, 3) the "projector beam", 4) the circumstellar torus, 5) the spot of scattered light which, at a favourable viewing angle, can be observed as a CN. The cross-section of the cylinder approximating the mass distribution of the torus is shown by the dashed line.

REFERENCES

Bally, J.: 1982, Astrophys. J. 261, 558.

Cantó, J., Rodríguez, L.F., Barral, J.F., Carral, P.: 1981, Astrophys. J. 244, 102.

Cohen, M.: 1974, Publ. Astron. Soc. Pacific 86, 813.

Cohen, M., Kuhi, L.V., Harlan, E.A.: 1977, Astrophys. J. 215, L127.

Cohen, M., Kuhi, L.V., Harlan, E.A., Spinrad, H.: 1981, Astrophys. J. 245, 920.

Gyulbudaghian, A.L.: 1982, Astrofizika 18, 660.

Gyulbudaghian, A.L., Magakyan, T.Yu., Amirkhanyan, A.S.: 1977, Soviet Astron. Lett. 3, 84.

Levreault, R.M.: 1984, Astrophys. J. 277, 634.

Magakyan, T.Yu.: 1981, Soviet Astron. Lett. 7, 219.

Papaloizou, J.C.B., Pringle, J.E.: 1983, Monthly Notices Roy. Astron. Soc. 202, 1181.

Ruzmaikina, T.V.: 1982, Mitt. Astron. Ges. 57, 49.

Uchida, Y., Shibata, K.: 1984, Publ. Astron. Soc. Japan 36, 105.

Ward-Thompson, D., Warren-Smith, R.F., Scarrott, S.M., Wolstencroft, R. D.: 1985, Monthly Notices Roy. Astron. Soc. 215, 537.

HIGH RESOLUTION CO OBSERVATIONS OF THE BIPOLAR NEBULA CRL2688

R. Kawabe[1,2], T. Kasuga[3], M. Ishiguro[3], K-I. Morita[3],
N. Ukita[3], H. Kobayashi[1], S. Okumura[1], E.B. Fomalont[3,4],
N, Kaifu[3]
[1]Department of Astronomy, University of Tokyo, Bunkyo-ku, Tokyo 113, Japan
[2]Department of Astrophysics, Nagoya University, Chikusa-ku, Nagoya 464, Japan
[3]Nobeyama Radio Observatory, Nobeyama, Minamimaki, Minamisaku, Nagano 384-14, Japan
[4]National Radio Astronomy Observatory, Edgemont Road, Charlotteville, VA 22901 USA

CRL2688 is suggested to be one of the proto-planetary nebulae which are probably at a stage in which the central star is evolving from the red giant phase with rapid mass loss (Zuckerman 1978). The bipolar shape in both the optical and H_2 emission indicates that a dense toroid of dust and gas obscures the star and surrounds the optical emission. The toroid is probably responsible for channelling the mass loss to the polar directions (Ney *et al.* 1975, Morris 1981, Beckwith *et al.* 1984). We present the results of mapping observations of CO (J = 1-0) emission from the expanding molecular envelope (Zuckerman *et al.* 1976, Lo *et al.* 1976, Knapp *et al.* 1982, Thronson *et al.* 1983) of the bipolar reflection