THE BALLISTIC PARTICLE MODEL

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THE MODEL

Bash and Peters (1976) suggested that giant molecular clouds (GMC's) can be viewed as ballistic particles launched from the two-armed spiral-shock (TASS) wave with orbits influenced only by the overall galactic gravitational potential perturbed by the spiral gravitational potential in the arms. For GMC's in the Milky Way, the model predicts that the radial velocity observed from the Sun increases with age (time since launch). We showed that the terminal velocity of CO observed from $\ell \simeq 30°$ to $\ell \simeq 60°$ can be understood if all GMC's are born in the spiral pattern given by Yuan (1969) and live 30 x 10^6 yrs. Older GMC's were predicted to have radial velocities which exceed observed terminal velocities.

In Bash, Green and Peters (1977) we assume that stars form in the GMC's, after some delay time, and that the stars continue in ballistic orbits which can be integrated over times less than a relaxation time. We made observations of CO in molecular clouds connected to young star clusters and used the cluster's main-sequence turn-off to determine its age. We found that very young clusters (earliest star is an O-star) still are inside the molecular cloud from which they were born while older clusters (earliest star is a B-star) show no evidence of their molecular cloud. This confirmed the suggestion of our earlier paper that GMC's disappear abruptly at a certain age. The lifetime determined above and the main-sequence lifetime of a B0 star allows the determination of the delay between GMC formation and star formation in the GMC.

Bash (1979) examined the optical surface brightness shapes of spiral arms predicted to result from stars born in our ballistic GMC's. The predicted surface brightness shapes agree well with observed ones and the agreement allows the initial-mass-function of spiral arm stars to be determined. Bash (1979) also determined, from observations of the Milky Way and M81, that the best agreement with the model is achieved when the molecular clouds are launched at the post-shock velocity and live for 40 x 10^6 yrs.

E. Athanassoula (ed.), Internal Kinematics and Dynamics of Galaxies, 133–134.

FURTHER TESTS

Bash, Hausman and Papaloizon (1981) suggest that ballistic molecular clouds will hit smaller interstellar clouds at relatively high velocities ($\sim$ 15 km s^{-1}) and that those collisions are capable of continuing to stir the GMC's internal turbulence.

Bash and Visser (1981) combined Visser's model for the HI gas in M81 with the ballistic particle model for GMC's and spiral arm stars. The resulting model predicts an optical surface brightness which resembles photographs of M81 and predicts HII region velocities which can be checked by observation.

Bash (1981) showed that observed Milky Way giant HII region radial velocities and galactic longitudes agree with predictions of the ballistic particle model which assumes that the Galaxy has two spiral arms and that the HII regions do not move on circular orbits.

Finally, Hilton and Bash (1982) showed that the observed vertex deviation of the velocity ellipsoid for B0 and B1 stars near the Sun is predicted by the ballistic particle model. The cause of the amount and the sense of the deviation is the initial post-shock velocity of the GMC's from which the stars were born and the fact that the stars are young enough to still "remember" their initial velocities.

Present work on testing the ballistic particle model focuses on comparing a set of detailed VLA and optical measurements of M81 to the predictions of our model and on a theoretical examination of how our model predicts the properties of the Hubble Types of spiral galaxies.

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