A Mechanism for the Production of Jets and Ansae in Planetary Nebulae

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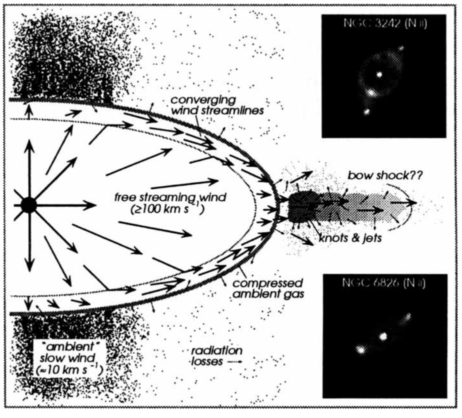
The general properties of elliptical planetary nebulae have been very successfully explained by a class of hydrodynamic models known as interacting stellar winds (ISW). PNs also contain a variety of microstructures (Anase,"FLIERs") whose origins have remained puzzling. We (Frank, Balick, & Livio 1996) have shown that such flows will naturally occur in the ISW model in momentum-conserving PPN bubbles, and that they can naturally account for the formation of jets and ansae in a way consistent with extant observations.

Our model relies on two points. First the recognition that the change in wind character from slow to fast occurs gradually. The reverse shock in the fast wind will be fully radiative so long as the the fast wind velocity < 160 km/s (Kahn & Breitschwerdt 1990). Second if the slow wind has an equator to pole density contrast then the bubble which forms will have a prolate elliptical geometry. Fast wind streamlines passing obliquely through this shock will become focused towards the axis. The post-shock flows converge at the axis where they collide forming a new shock which redirects the flow into a jet moving outward along the long axis of the bubble in manner described by Canto, Tenorio-Tagle,& Rozycska (1988). When the velocity of the fast wind becoms larger than 160 km/s the reverse shock becomes non-radiative. The temperatures become high and flows now converge inside a "hot bubble". The high sound speed in the hot bubble acts quickly to suppress the formation of any density inhomogeneities. Thus the era of dense low-ionization jet and ansa formation comes to a close. A schematic diagram for our model is shown in Fig 1. Our calculations show that the expected sizes, velocities, and ionization of these microstructures conform quite nicely to observations.



REFERENCES

Canto,J., Tenorio-Tagle,G., & Rozyczka M. 1988. A&A 192 287

Kahn, F.D., & Breitschwert, D. 1990, MNRAS 242 505

Frank, A., Balick, B., & Livio, M., 1996, ApJ, 471, L53

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