Red Giant Mass Loss and Planetary Nebula Formation

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It is generally believed that red giant mass loss plays some role in the formation of planetary nebulae (PNe), but the connection is not clearly understood. To investigate this issue we have undertaken an extensive search for molecular gas in PNe, which is likely to be remnant material of the red giant wind not yet ionized by the central star. The search has been carried out with the NRAO 12 m telescope in the 1.3 mm line of CO which is widely observable in the molecular winds of red giants.

About 100 PNe have been observed, and CO has been detected in 19, a few being tentative. New detections (with LSR radial velocities in km/s and line strengths in K km/s) include: IC 5117 (-10, 4.6), NGC 2440 (+44, 3.6), NGC 2474 93" NW (-70, 3.2), NGC 6072 (+15, 29), NGC 6445 (+20, 11), NGC 6563 (-27, 19), IRAS 21282 + 5050 (+18, 40), M1-7 (-11, 17), M1-16 (+50, 26) and M4-9 (-16, 13). Earlier results on NCC 2346, NGC 6720, and NGC 7293 have been given elsewhere (Healy and Huggins 1988, A.J., 95, 866, and references therein). The number observed is now large enough that some general conclusions can be drawn. First, molecular envelopes are a fairly common property of PNe. Second, nebulae with massive molecular envelopes are almost exclusively young population objects as evidenced by their morphological types, nitrogen abundances, and positions of the central stars on the H-R diagram. Third, the PNe detected cover a wide range in molecular mass (thousandths to tenths of solar mass) and nebular size (from compact objects to very extended nebulae); their mass ratio of molecular to ionized gas decreases systematically over four orders of magnitude with increasing radius, indicating that the mass of the optical nebula grows as the molecular gas becomes ionized. For these objects the molecular envelope plays a key role in the evolution of the nebulae.