MOLECULAR-LINE OBSERVATIONS OF THE REMNANT AGB ENVELOPES AROUND PLANETARY NEBULAE

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ABSTRACT: We present recent results from a "search and mapping" program of molecular line emission (mainly CO) from remnant AGB envelopes around planetary nebulae (PNe), using the SEST (La Silla, Chile). New detections in CO J=2-1 include NGC2899 (0.02K), NGC6369 (0.14K) & NGC7009 (0.08K). In many of the detected PNe, notably NGC3132, IC4406, NGC6302, M1-16, and CPD-56°8032, the molecular envelopes contain 2 kinematically distinct outflows. Mapping of the strongest of these shows (1) that the fast (e.g. $V_{exp} \gtrsim$40-60 km s^{-1} in NGC3132, IC4406) outflows have bipolar spatial structure, and (2) there exists an equatorial density enhancement in the slower, more massive [$\dot{M}$ ($M_\odot yr^{-1}$)>5 10^{-6}(NGC3132), >2 10^{-5}(IC4406)] outflows, which presumably collimates the fast outflow (e.g. Sahai et al. 1990, A & A, 234, L1; Sahai et al. 1992, A & A, 251, 560). The fractional CO abundance in the envelope, f(CO), is probably rather low (<10^{-4}), as a result of photodissociation by the stellar and interstellar UV radiation [e.g. f(CO)$\lesssim 10^{-5}$ in IC4406]. HCN, HCO^+, and ^{13}CO have also been detected in several PNe, and sensitive upper limits set on CS, $C^{18}O$, & $C^{17}O$ (in M1-16), and SO (in NGC3132). Some results are tabulated below, and calculations to estimate the molecular masses, mass-loss rates and molecular abundances are in progress.

Mol./Line	Data	V_c[a]	ΔV[b]	ΔV_{hi}[c]	T_{mb}(K)	Comments
M: Map, S: Spectrum			M1-16			
CO J=2-1	M	50.5	44	60	1.8	HVW[d], B[e] (NW-SE)[f], opt. thick
CO J=1-0	S	50.5	43	60	0.43	HVW, opt. thick
^{13}CO J=1-0	S	50.2	38	--	0.14	$[^{12}C]/[^{13}C]<10$, $\dot{M}>10^{-4}$ $M_\odot yr^{-1}$?
HCN J=1-0	S	≈50	≈43	160?	0.025	Very high-vel(-20 to 140) emission?
HCO^+ J=1-0	S	≈50	≈43	≈70	0.043	
N_2H^+ J=1-0	S	≈47	≈31	--	0.03	Double-peaked line?(marginal det.)
			CPD-56°8032			
CO J=2-1	M	-57	50	186	0.58	HVW, B (NWW-SEE), opt. thick
CO J=1-0	S	-57	50	120	0.13	HVW
^{13}CO J=1-0	S	≈-57	≈50	--	0.04	$[^{12}C]/[^{13}C]<10$, $\dot{M}>10^{-4}$ $M_\odot yr^{-1}$?
HCO^+ J=1-0	S	≈-57	≈50	--	≈0.035	
			NGC3132			
CO J=2-1	M	-25	30	70	0.35	HVW, B (≈NW-SE), opt. thick
CO J=1-0	S	-25	30	70	0.24	HVW, opt. thick
^{13}CO J=1-0	S	≈-25	≈18	--	0.035	
HCO^+ J=1-0	S	≈-23	≈55		0.045	Broad profile
			NGC6302			
CO J=2-1	M	-36	60	110	0.9	HVW, B Expanding Lobes (≈E-W)
CO J=1-0	M	≈-30	≈55	≈100	≈0.25	(contamination from I.S. emission)
HCO^+ J=1-0	S	≈-36	≈30	--	0.025	
HCN J=1-0	S	≈-40	≈40	--	0.025	

a– VLSR (km s^{-1}); b & c– Full-widths at zero intensity (km s^{-1}) of main & high-velocity components in central spectrum; d– High-vel. wings in spectrum; e (f)– Bipolar (axis)

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