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H_2CO and CS in planetary nebulae

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1. Introduction

Molecular abundances around planetary nebulae (PNe) are usually low, since the high flux of ionising radiation coupled with an expanding, increasingly diffuse envelope precludes high molecular abundances arising. However, a few species are detected, most noticeably CO, which self-shields, and can still be abundant in the PN phase. Others include HCN, HNC, CN, C_2H, HCO^+, and N_2H^+ (c.f., Bachiller et al. 1997, Josselin & Bachiller 2003). These and other species may survive due to the clumping of circumstellar matter, and clumps have been observed in the Helix nebula (Huggins et al. 1992), for example. Moreover, chemical models do show that (mostly small) molecular species can be abundant due to the shielding effects of clumps (e.g., Redman et al. 2003, Howe et al. 1994).

Here we present what we believe to be the first detections of carbon sulphide (CS) and formaldehyde (H_2CO) in planetary nebulae. Observations were taken between 2000 and 2002 with the SEST, located on La Silla, Chile. Formaldehyde is detected in two sources, IC4406 and NGC6072, whilst CS is only detected in IC4406. Several other species are also detected. We present integrated intensities and calculated fractional abundances in Table 1.

2. Results

Using standard methods (c.f., Woods et al. 2003), we have estimated fractional abundances in the two PNe, and these are compiled in Table 1. These fractional abundances in general seem high, which could be due to the non-spherical geometry of these sources, or errors in mass-loss rate or distance. Fractional abundance ratios are more robust than fractional abundances, since there is less of a dependence on mass-loss rates and distances, and our ratios (relative to HCN) are in very good agreement with those of Cox et al. 1992.

Table 1. Integrated intensities and calculated fractional abundances of detected lines. Key: C91 (Cox et al. 1991), C92 (Cox et al. 1992)

Molecule	Transition	Frequency GHz	IC4406 $T_{\rm mb}$ K	IC4406 $\int T_{\rm mb}{\rm d}v$ K km s^{-1}	IC4406 f(X)	NGC6072 $T_{\rm mb}$ K	NGC6072 $\int T_{\rm mb}{\rm d}v$ K km s^{-1}	NGC6072 f(X)	Previous Detections
C_2H	N=1-0	87.329	0.01	0.51	1.1 (-5)	0.03	2.27	5.7 (-5)	
HCN	J=1-0	88.632	0.08	2.33	3.9 (-6)	0.11	3.74	8.2 (-6)	C92
HCO^+	J=1-0	89.189	0.06	2.23	1.3 (-6)	0.13	3.09	2.1 (-6)	C92
HNC	J=1-0	90.664	0.03	0.53	6.2 (-7)	0.06	1.36	1.9 (-6)	C92
^{13}CO	J=1-0	110.201	0.02	0.41	5.6 (-5)	—	—	—	C92
CN	N=1-0	113.491	0.10	7.81	1.4 (-5)	0.22	13.92	2.9 (-5)	C92
CO	J=1-0	115.271	0.36	8.33	9.5 (-4)	0.73	14.21	2.3 (-3)	C92
H_2CO	$2_{1,2}$-$1_{1,1}$	140.840	0.03	0.74	4.5 (-6)	0.05	0.29	2.1 (-6)	
CS	J=3-2	146.969	0.01	0.23	1.4 (-7)	—	—	<1.8 (-7)	
^{13}CO	J=2-1	220.399	0.17	2.21	2.7 (-5)	—	—	—	
CN	N=2-1	226.875	0.34	14.22	2.4 (-6)	0.36	10.68	2.1 (-6)	
CO	J=2-1	230.538	1.55	29.00	3.0 (-4)	2.33	35.60	5.3 (-4)	C91
HCN	J=3-2	265.886	0.23	4.11	2.1 (-7)	—	—	—	
HCO^+	J=3-2	267.558	0.18	2.76	4.5 (-8)	0.18	0.24	4.5 (-9)	

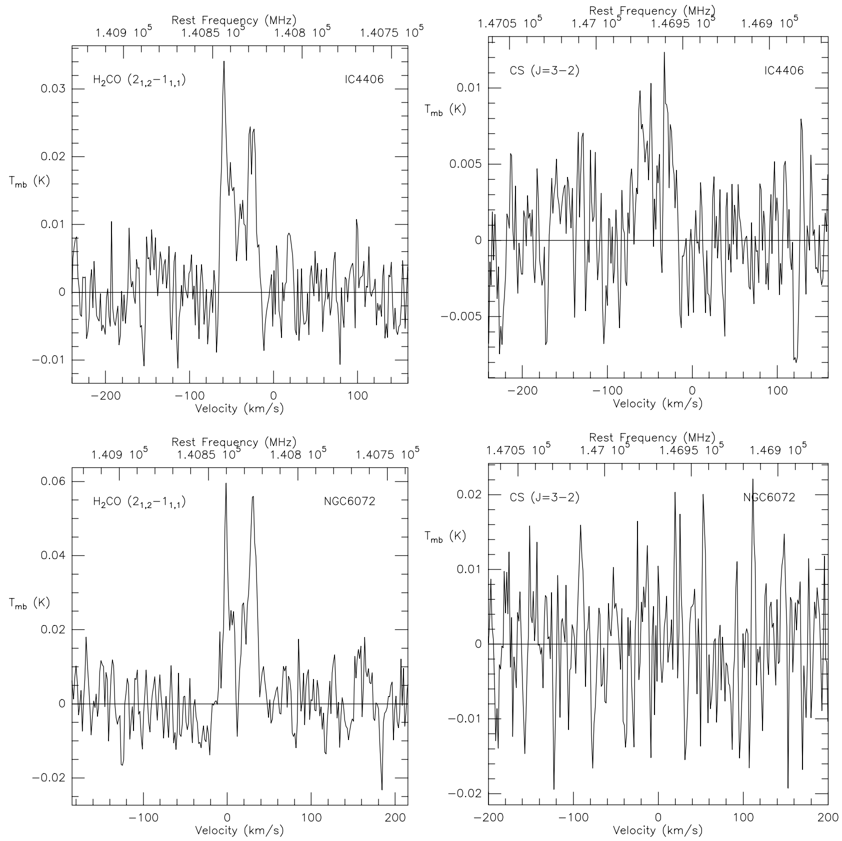

Figure 1. Left. SEST spectra of the H_2CO ($2_{1,2}$-$1_{1,1}$) line towards IC4406 (top) and NGC6072 (bottom). **Right.** SEST spectra of the CS (J=3-2) line towards IC4406 (top) and NGC6072 (bottom). The bottom spectrum is a non-detection.

3. Conclusion

The new detections of these two species, CS and H_2CO, in planetary nebulae strengthens the argument for high degrees of (localised) shielding throughout the post-AGB phase of evolution, such as that found in clumps. Outside of these clumps, the strong radiation field (indicated by high HCO^+ abundances) from both the central star and interstellar space makes the survival of complex species difficult (Woods et al. 2005).

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