PLANETARY NEBULAE: THEIR EVOLUTION AND ROLE IN THE UNIVERSE
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Imaging and Spectroscopy of Type I Planetary Nebulae

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Abstract. Optical spectra and images in the main optical emission lines were obtained for 21 type I planetary nebulae (PNe). IR images directed towards the detection of shocked molecular hydrogen were secured in 17 of these objects. No evidence of shocked H2 could be found in A 14 and Sh 2-71, and its existence needs to be confirmed in JnEr 1 and M 1-57. Bipolarity is obvious in most of these sources. A 24, JnEr 1 and M 3-5 may be bipolars seen nearly pole-on. The chemical composition of nearly half of these objects indicates that third dredge-up episodes may have occured in their progenitor star. The presence of shock waves in the ionized component is inferred in 9 PNe, where the temperature ratio $T(O^{+2})/T(N^{+})$ is large and the Hα/[S II]6724 line ratio small, a typical combination in shock excited plasmas. A larger sample of type I PNe shows that small Hα/[S II]6724 line ratios are usually associated with large temperature ratios.

1. Introduction

In order to further explore the properties of type I PNe, optical spectra, images in the main optical emission lines and IR images directed towards the detection of molecular hydrogen, were obtained for 21 of these objects. These observations were carried out at the Observatorio Astronómico Nacional at San Pedro Mártir, B.C., Mexico (OAN). An extended account of nearly half of these objects has been published (Bohigas 2001).

2. Results

Some of the properties of these type I PNe are presented in Table 1, where the following is reported:

H_2: shocked molecular hydrogen with Y = present, N = absent, ? = undecided.

N_e: electron density in cm^{-3}.

$T(N^{+})$: electron temperature derived from [N II](6548 + 6584)/5755.

TR: $T(O^{+2})/T(N^{+})$, where $T(O^{+2})$ is the electron temperature derived from [O III](4959 + 5007)/4363.

HS: Hα/[SII]6724.

He/H: helium-to-hydrogen abundance ratio.

N/O: nitrogen-to-oxygen abundance ratio.

Ne/H: neon-to-hydrogen abundance ratio in 10^{-4} units.

T_c: central star temperature in 1000 K, using the method prescribed by Kaler & Jacoby (1989).

Table 1. General properties

Object	H_2	N_e	$T(N^+)$	TR	HS	He/H	N/O	Ne/H	T_c
A 14	N	<10	12500		3.34	0.217	1.53		169
A 24	?	<10	9100		2.76	0.187	3.95	2.93	<126
A 79	Y	225	11300	1.35	1.21	0.265	1.89	2.23	176
BV 5-1	Y	540	12000	1.48	1.55	0.185	1.80	0.86	219
JnEr 1	?	<10	9800	1.08	8.51	0.165	0.39	2.94	129
K 3-46	Y	140	10400		1.64	0.191	2.49	2.62	116
K 3-72	Y	185	9300	1.10	4.30	0.157	5.17	1.45	<136
K 3-91	Y	690	11900		15.4	0.191	1.59		231
K 3-94	Y	265	12500	1.30	3.54	0.153	0.85	0.58	157
K 4-55	Y	670	11800	1.38	2.67	0.173	3.47	0.61	<201
M 1-28	Y	580	9800	1.45	2.36	0.134	3.43	1.10	<158
M 1-41	Y	2060	13000	1.37	2.59	0.142	1.82	0.57	190
M 1-57	?	4760	13800	1.04	4.82	0.137	0.96	1.25	<191
M 1-75	Y	750	10300	1.35	2.24	0.180	2.27	1.96	358
M 2-52	Y	950	12600	1.21	2.67	0.147	1.83	1.01	210
M 3-3	Y	230	9300	1.25	19.4	0.138	1.76	1.05	114
M 3-5	Y	970	12600	1.06	17.2	0.135	1.20	0.62	158
NGC 2818	Y	60	10300	1.75	1.46	0.213	0.98	1.53	160
Sh 1-89	Y	150	7600	1.41	4.98	0.129	0.38	5.85	129
Sh 2-71	N	260	11400	1.38	1.22	0.199	3.03	1.31	197
We 1-4	Y	<10	12400		4.18	0.173	1.11		154

References

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