AN ATLAS OF EMISSION LINE FLUXES OF PLANETARY

NEBULAE IN THE 1150-3200Å REGION

A. Boggess, W. A. Feibelman and C. W. McCracken
Laboratory for Astronomy and Solar Physics
Goddard Space Flight Center

ABSTRACT

Emission line fluxes in units of 10^{-12} erg $cm^{-2}sec^{-1}$ for 28 planetary nebulae are presented. The nebulae were chosen to cover a wide range of excitation classes, apparent diameters, location in the sky, and types of central stars. All objects were observed in the low-dispersion mode of the IUE spectrographs, using the large entrance aperture.

INTRODUCTION

Ultraviolet observations have an important role to play in the study and interpretation of planetary nebulae. The range from 1200 to 3200Å contains lines of carbon, nitrogen, oxygen and silicon in ionization stages difficult to observe from the ground. In addition, forbidden lines from ions such as three and four times ionized neon and argon provide opportunities for probing the high temperature regions of these objects. The first spectra obtained of planetaries throughout this range were those of NGC7027 and NGC7662, by Bohlin and his collaborators using sounding rockets (1, 2). However, it has only been with the advent of the IUE that such data could be obtained routinely for a large number of nebulae to $m_v \approx 12$. With this in mind, a systematic program of observing planetary nebulae has been conducted during the first two years of IUE operations in order to provide data on these objects covering a wide range of excitation class, apparent diameter, and spectral type of the central star. The results presented here are from low dispersion observations of 28 planetary nebulae. Intensities of the emission lines in these objects are given in the accompanying tables. Plots of the actual calibrated spectra will be published elsewhere.

OBSERVATIONS

All the planetary nebulae listed in the accompanying tables have been observed in the low-dispersion mode, corresponding to a resolution of about 7Å, through the 10"x20" large apertures, with the nebulae centered in the aperture. Thus the resulting data correspond essentially to slitless spectra of the nebulae and their central stars. The majority of the objects (about 75%) are small enough so that the measured fluxes represent those of the entire nebula. Many of the nebulae have been observed more than once to extend the dynamic range of the data, and in these cases the fluxes tabulated are from the spectrogram yielding the best signal-to-noise ratio for the line in question.

The fluxes have been generated from the net extracted spectra and corrected, when necessary, for ITF errors. The data have been converted to absolute units using the calibration curve of Bohlin, et al. (3). All the spectra were processed for "extended source extraction" in order to measure the total emission in the entrance aperture, even when the nebula was known to be small or semi-stellar. As a test, a few of these small objects were processed in both "extended source" and "point source" extraction and the results were identical, as one would expect. For those objects that exceed the entrance aperture dimension, allowances have to be made to convert the measured fluxes into actual percentages of the entire flux emitted by the nebula and the position angle may have to be considered, too.

The tabulated emission line fluxes are believed to have internal accuracies of ±10%, except for those values shown in brackets where the accuracy may be on the order of ±20%. This lower accuracy is usually due to weaker lines with low S/N ratio or because of high-radiation backgrounds during the time of observation. To these errors, one must add the uncertainty of the IUE absolute calibration, which is estimated to be about 10%. No corrections for interstellar extinction have been applied. The presence of geocoronal Ly-α on all spectra prevents any measurements of nebular features within ~ 15Å of Ly-α.

Although determinations of intensity ratios of doublets for establishing electron densities or electron temperatures, line profiles, expansion velocities and line splitting will require high-dispersion spectrograms of the objects studied so far, there are nevertheless some preliminary conclusions that can be drawn from the low-resolution spectra. The sampling of 28 objects is sufficiently large to make some general statements: 1) There are remarkable differences among the UV spectra even between objects of similar excitation class and extinction. 2) All nebulae show CIII] λ1907-09 and this feature can be used as an indicator in surveys for nebular emission objects. 3) Objects that are classified as low-excitation nebulae in the visible generally show the emission lines of CIII], [OII] and MgII. 4) HeII may be present in both low- and high-excitation nebulae, and a few planetaries show mixtures of both very high- and low-excitation lines. 5) Those classified as high-excitation objects show NV, [NeIV], and [MgV] lines.

RESULTS

In the accompanying tables the nebulae have been grouped roughly according to excitation class. The tables give excitation classes and nebular diameters from Lang (4) and spectral types of central stars from Aller (5). All entries give the measured emission line fluxes in units of 10^{-12} erg cm^{-2} sec^{-1}. Fluxes of lower accuracy are shown in brackets. Letter entries in the tables are defined as follows:

- a = absorption line
- b = blended lines
- p = emission component of P-Cygni feature
- s = a few pixels saturated
- WR = broad emission feature of Wolf-Rayet type
- z = line is probably present.

REFERENCES

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Table 1

Emission Line Fluxes for Low Excitation Planetary Nebulae

		BD 30°3639	IC418	IC2149	IC3568
Diameter (arcsec)		3.0	12.4	8.6	18
Excitation Class		1	3	4	5
Central Star		WC9	07fp	07.5fp	05f
1239/41	NV	7.71	-	-	-
1309	SiII	9.60	-	-	-
1335	CII	6.64	(21.85)	-	-
1403/09	OIV]	4.57	-	-	-
1487	NIV]	5.14	-	3.93	-
1548/50	CIV	a	16.64p	3.05p	3.42p
1640	HeII	5.23	-	-	-
1661/66	OIII]	2.91	-	-	-
1674	?	3.80	-	-	-
1747	NIII	5.78	-	-	-
1892	SiIII	4.23	-	-	-
1907/09	CIII]	44.63	29.92	4.94	7.11
2297	CIII	28.59	-	-	-
2325/29	CII], [OIII]	20.37	82.52	2.08	-
2470	[OII]	-	27.50	1.19	-
2798	MgII	-	29.75s	-	-
2830	HeI	12.78	-	-	-
3047	OIII	-	1.23	-	-
3095	?	-	6.64	-	-
3133	OIII	-	6.64	-	-
3188	HeI, OIII	-	-	z	(0.27)

Table 2

Emission Line Fluxes From Moderately High Excitation Planetary Nebulae

		J320	IC4846	NGC6891	Hu 2 - 1	NGC7026
Diameter (arcsec)		6.4	2.0	12.6	-	11.2
Excitation Class		5	5	5	-	6
Central Star		-	-	07f	-	OVI
1309	SiII	-	-	-	(0.15)	(0.04)
1371	OV	-	-	-	-	0.30
1487	NIV]	(0.55)	-	(1.67)	-	0.12
1548	CIV	5.41	-	3.86p	a	0.83
1640	HeII	1.88	-	-	-	0.67
1661/66	OIII]	-	-	-	-	-
1718	NIV,SiII]	-	-	(0.41)	-	-
1747	NIII	-	-	-	(0.19)	-
1892	SiIII	0.20	-	-	-	-
1907/09	CIII]	7.76	0.47	3.12	1.77	0.49
2325/29	CII], [OIII]	1.07	(0.43)	-	1.94	-
2423/26	[NeIV]	0.52	-	-	-	-
2470	[OII]	-	(0.70)	-	(0.98)	-
2734	HeII	(0.30)	(0.90)	-	-	-
2946	HeI	(0.22)	-	-	-	-
3047	OIII	0.49	(0.39)	-	z	-
3133	OIII	2.32	-	(0.84)	-	1.17
3188	HeI,OIII	-	(0.17)	(0.88)	2.21	-

Table 3

Emission Line Fluxes for Moderately High Excitation Planetary Nebulae

		NGC6572	IC4997	NGC6565	NGC6644	NGC3132
Diameter (arcsec)		16.4	1.6	9.0	2.6	(56)
Excitation Class		5	5	6	6	6p
Central Star		Of+WR	Of+WR	-	-	A+sdO
1239/41	NV	(2.33)	0.56	0.29	-	-
1309	SiII	0.82	(0.93)	-	-	-
1335	CII	z	0.29	-	0.31	-
1371	OV	1.91	-	(0.81)	-	-
1403/09	OIV]	(1.03)	0.09	-	-	-
1487	NIV]	z	0.15	-	-	-
1548/50	CIV	2.66p	3.51	0.78	9.50	-
1575	[NeV]	-	-	0.44	-	-
1640	HeII	1.57	0.34	2.04	2.39	6.62
1661/66	OIII]	0.95	5.11	-	0.89	0.74
1718	NIV, SiII]	2.03	-	-	-	z
1747	NIII	1.32	2.16	0.48	-	0.75
1817	[NeIII] ,SiII	-	0.23	-	-	-
1892	SiIII	(0.72)	0.33	-	-	-
1907/09	CIII]	50.52s	17.67	2.55	12.31s	4.21
2252	HeII	-	0.26	-	-	-
2325/29	CII], [OIII]	10.47	2.35	0.98	1.71	-
2423/26	[NeIV]	-	-	(0.37)	0.71	-
2470	[OII]	5.62	1.59	(0.49)	0.60	-
2511	HeII	-	z	-	-	-
2734	HeII	-	z	-	-	(0.58)
2798/03	MgII	-	1.90	-	1.66s	-
2830	HeI	1.84s	0.33	-	0.24	(0.33)
2852	MgI	-	z	-	-	-
2946	HeI	(0.70)	0.38	-	-	-
3047	OIII	-	(0.18)	(0.33)	-	-
3133	OIII	-	-	1.12	2.65	2.27
3188	HeI,OIII	2.33	-	-	(0.98)	-
3204	HeII	-	(1.96)	-	-	-

Table 4

Emission Line Fluxes for High Excitation Planetary Nebulae

		NGC1535	J900	NGC3242	IC1297	HM Sge*	NGC7009
Diameter (arcsec)		18.4	9.4	(40)	-	-	26.8
Excitation Class		7	7	7	-	-	7p
Central Star		07	em?	cont?	-	-	cont.
1239/41	NV	29.71	(0.23)	5.63	-	0.87	21.91
1286	?	(2.98)	-	-	-	-	-
1309	SiII	(3.46)	-	-	-	-	-
1335	CII	-	(0.24)	-	-	(0.09)	-
1371	OV	7.82	-	(1.06)	2.41	0.35	4.98p
1391	SiIV	-	-	-	-	0.25	-
1403/09	OIV]	(3.43)	(0.18)	-	0.68	0.31	-
1487	NIV]	-	0.51	(3.85)	z	1.15	z
1548/50	CIV	10.74	5.23	-	7.62	5.02	10.86
1575	[NeV]	z	-	-	0.42	(0.12)	4.36
1640	HeII	14.30	1.68	118.30	14.98	3.44b,WR	43.00
1661/66	OIII]	z	(0.24)	-	1.38	2.66b	3.68
1718	NIV,SiII]	-	-	-	-	2.07b,WR	-
1747	NIII	7.84	-	-	1.30	5.15b	1.29
1817	[NeIII],SiII	-	-	-	-	0.57	-
1892	SiIII	-	(1.10)	-	0.41b	3.04b	-
1907/09	CIII]	8.26	7.51	98.13	7.02b	10.09b	25.70
2101	CIII	-	-	(0.93)	-	-	-
2252	HeII	-	-	0.87	-	-	-
2297	CIII	-	-	5.19	-	-	2.60
2325/29	CII],[OIII]	-	1.07	2.01	0.90	1.67	1.93
2423/26	[NeIV]	-	0.52	9.15	0.70	0.36	1.93
2470	[OII]	-	-	-	-	0.22	-
2511	HeII	-	-	0.85	z	-	(0.64)
2734	HeII	-	0.30	2.45	0.52	0.20	1.73
2784	[MgV]	-	-	-	(0.71)	-	-
2798/03	MgII	-	-	-	-	7.16	-
2830	HeI	1.18	-	3.33	0.77	1.75	3.68
2946	HeI	-	-	-	-	-	1.17
3024	OIII	-	-	2.65b	-	-	(0.97)b
3047	OIII	-	0.50	6.04b	0.47	0.19	3.99b
3133	OIII	3.81	2.30	36.18s	4.41	0.43	24.81
3188	HeI,OIII	-	-	-	(1.18)	-	3.21b
3204	HeII	-	z	6.41	-	z	3.56b

*The fluxes of HM Sge are for the first set of observations, 6 June 1978. Considerable changes have occurred during the past two years and will be described elsewhere.

Table 5

Emission Line Fluxes for Very High Excitation Planetary Nebulae

		IC2165	NGC3211	NGC6818	NGC7027	Hu 1 - 2
Diameter (arcsec)		8.0	13.8	18.4	14.2	5
Excitation Class		9	8	9	10p	10
Central Star		cont?	?	cont.	-	-
1239/41	NV	0.44	0.46	0.47	(0.71)	0.71
1309	SiII	-	-	-	1.21	-
1335	CII	-	0.17	-	z	-
1391	SiIV	-	-	(1.54)	-	-
1403/09	OIV]	0.82	1.74	-	-	0.54
1487	NIV]	1.02	1.72	2.22	0.65	1.85
1548/50	CIV	21.95	4.42	7.05	17.06	5.49
1575	[NeV]	-	-	z	-	-
1640	HeII	6.71	14.90	21.88s	3.47	5.55
1661/66	OIII]	0.62	1.12	1.78	z	-
1747	NIII	0.63	1.07	1.51	-	1.53
1817	[NeIII],SiII	0.18	-	-	-	-
1892	SiIII	z b	z b	0.67	z b	-
1907/09	CIII]	21.84bs	28.83b	35.92	9.64b	3.95
2252	HeII	1.00	-	-	1.03	-
2297	CIII	-	-	0.21	-	-
2325/29	CII], [OIII]	1.36	1.21	2.11	1.90	0.43
2423/26	[NeIV]	2.70s	5.44s	8.37	1.02	2.26
2470	[OII]	-	-	-	0.53	-
2511	HeII	0.28	0.29	0.57	-	0.22
2734	HeII	1.31	0.96	1.23	0.49	0.36
2784	[MgV]	0.37	0.27	0.50	2.29b	-
2830	HeI	0.86	0.34	0.72	0.40b	-
2929	MgII	-	-	0.11	0.27	-
3024	OIII	0.36	-	0.54	0.67	-
3047	OIII	1.80	0.80	1.20b	1.17	0.37
3133	OIII	9.83s	4.23	8.33	11.03	0.87
3204	HeII	2.40	(2.12)	3.30	1.61	(1.00)