Rev. Mexicana Astron. Astrof., 8, 187-192 (1983)

PHOTOELECTRIC, ABSOLUTE Hβ FLUXES FOR 55 PLANETARY NEBULAE

L. Carrasco, A. Serrano, and R. Costero

Instituto de Astronomía
Universidad Nacional Autónoma de México

Received 1983 July 8

RESUMEN

Se reportan mediciones fotométricas de banda angosta del flujo integrado en la línea de emisión Hβ para 55 nebulosas planetarias. De esta muestra, 17 nebulosas no tenían flujos determinados con buena precisión y otras 15 no tenían mediciones reportadas anteriormente.

ABSTRACT

We have carried out narrow-band photoelectric photometry in order to obtain the integrated Hβ absolute fluxes for 55 planetary nebulae, 17 of which did not have accurate measurements. Other 15 nebulae did not have any earlier measurements.

Key words: PLANETARY NEBULAE — PHOTOMETRY

I. INTRODUCTION

The knowledge of integrated absolute Hβ fluxes in planetary nebulae provides us with an important tool for studying the statistical properties of this type of objects. The determination of their total Hβ fluxes is of key importance in connection with the mass of the emitting nebula, the distance scale and the interstellar and internal extinction for these objects. Unfortunately, the measured fluxes published earlier are not of uniform quality: errors in the observations introduce a high noise level in the statistical properties rendering more difficult the comparison with theory. Hence, we have undertaken the program of putting the Hβ total fluxes of planetary nebulae on a uniform scale, with small observational errors, and to enlarge the number of planetary nebulae with good quality measured Hβ fluxes in this and in future papers. In this first paper we present the fluxes for 55 planetaries. In the near future, we expect to determine absolute Hα fluxes, in order to determine the amount of extinction to individual objects and therefore distances and densities.

II. THE OBSERVATIONS

Most of the observations reported here were carried out during ten nights in two separate observing runs in April and December 1982, in the 84-cm telescope of the Observatorio Astronómico at San Pedro Mártir, Baja California. Further observations were made during four nights in February and March 1983, in the 1-m telescope at Tonantzintla, Puebla.

The San Pedro Mártir observations were done with a single channel photometer operating in pulse counting mode. This photometer was equipped with an RCA C31034 (GaAs) photomultiplier along with a 30 Å HPW interference filter centered at λ4861. The Tonantzintla observations were made with a two-channel, photon counting photometer, equipped with an uncooled RCA 8850 photomultiplier along with the interference filter described above.

These photometric systems could yield accurate nebular fluxes in those cases in which the contribution of nebular continuum in the 30 Å bandpass is negligible as compared with the Hβ flux. In order to determine total absolute fluxes, observations were carried out with a diaphragm selection appropriate to include the entire nebula; sky measurements were taken in carefully selected star-free nearby fields. In cases in which the contribution of the exciting central star was considered important, measurements of the stellar contribution were performed and subtracted from the combined flux.

TABLE 1

NEBULAE ADOPTED AS STANDARDS

Object	Adopted − log F(Hβ)	Reference
NGC 1747	11.53	O'Dell (1963)
IC 351	11.44	Capriotti and Daub (1960)
NGC 2003	11.21	O'Dell (1963)
J 900	11.31	Capriotti and Daub (1960)
NGC 2022	11.18	O'Dell (1963)

The flux of the exciting star was obtained through measurements with small apertures, typically 4 arc seconds, with sky subtraction of the nearby nebula.

Determinations of the atmospheric extinction at λ4861 were done nightly and the calibration of the photometric zero-point for our system was obtained by fits of our instrumental fluxes, corrected for atmospheric extinction, to the absolute fluxes determined by O'Dell (1963) and Capriotti and Daub (1960) for selected nebulae, used as standards and listed in Table 1.

We adopted the absolute calibration of Vega given by Hayes and Latham (1975), which is 0.03 fainter –in log F(Hβ)– than the calibration by Code (1960) used in the data reduction by O'Dell (1963) and by Capriotti and Daub (1960). Consequently, for those nebulae used as standards (Table 1), we have adopted values of log F(Hβ) 0.03 fainter than those listed by O'Dell and by Capriotti and Daub.

III. RESULTS

The total logarithmic Hβ fluxes in erg cm^{-1} s^{-1} obtained for 55 planetary nebulae by the previously outlined procedure, are listed in Table 2; along with the site of observations (where S stands for San Pedro Mártir and T for Tonantzintla Observatories), the diameter of the aperture used (in arc seconds), the number (N) of observations and all the published measurements known to us for the objects. The nebulae for which we have subtracted the contribution to the flux of the exciting star are marked with an asterisk; in Table 3 we present the total flux (star plus nebula) and the corresponding nebular flux estimated for these objects.

In Table 4 a comparison is presented for the objects in common with other observers, whenever the number of such objects is five or more. It must be noted that, although we have adopted as standards some nebulae in common with O'Dell, there is a zero-point shift in the

TABLE 2

TOTAL Hβ FLUXES OF PLANETARY NEBULAE

PK	Object	Site	ϕ ap (arc sec)	– log F(Hβ)	N	Other Measurements – log Fβ	Other Measurements References
0+17°1	PC 12	S	74	11.56	1	...	...
13+32°1	Sn 1	S	37	11.69	1	11.72	B 78
25+40°1	IIC 4593	S	37	10.54	1	10.59	CD 60
118–8°1	Vy 1-1	S	28	11.50	2	11.70	K 76
119–6°1	Hu 1-1	S	37	11.63	1	11.58	B 78
120+9°1	NGC 40	S	74	10.37*	2	10.64	Li 55
130–11°1	M 1-1	S	37	11.88	2	11.55 11.94	ALi 68 B 78
130+1°1	IC 1747	S	28	11.48	1	11.50 11.58	OD 63 K 76
131–5°1	BV 3	S	92	12.28	1	...	...
133–8°1	M 1-2	S	28	11.77	2	11.99 11.92 11.88	Ad 75 B 78 K 83
138+2°1	IC 289	S	74	11.63*	3	11.67 11.67	OD 63 KAC 76
144–15°1	A 4	S	55	12.39	1	...	...
146+ 7°1	M 4-18	S	28	11.77	2	11.88	K 83
147– 2°1	M 1-4	S	28	12.26	1	12.14	K 83
147+ 4°1	M 2-2	S	28	12.10	2	12.22	K 83
159–15°1	IC 351	T	39	11.44	2	11.41	CD 60
161–14°1	IIC 2003	S T	28 27	11.23 11.22	2 1	11.18 11.19	OD 63 B 78
169– 0°1	IIC 2120	S	74	12.22	1	...	...
171–25°1	Ba 1	S	55	12.33	1	...	...
174–14°1	H 3-29	S	74	12.47	2	12.49	K 83
176+0°1	NGC 1985	S	74	12.20*	3	...	...
184–2°1	M 1-5	S	55	12.04	1	12.05	B 78
189+ 7°1	M 1-7	S	55	11.82	3	12.05	K 83
190–17°1	J 320	T	27	11.39	1	11.38 11.45 11.39	CD 60 K 76 B 78
193–9°1	H 3-75	S	55	12.25*	3	...	...
194+2°1	J 900	S	28	11.28	1	11.28 11.34	CD 60 K 83

TABLE 2 (CONTINUED)

PK	Object	Site	ϕap (arc sec)	– log F(Hβ)	N	Other Measurements – log Fβ	Other Measurements References
196–10°1	NGC 2022	S	55	11.13	1	11.15	OD 63
						11.10	KoM 81
197–14°1	K 1-7	S	92	12.11	1	...	...
197+17°1	NGC 2392	S	92	10.29*	2	10.39	Li 55
						10.57	K 83
206–40°1	NGC 1535	S	74	10.44*	2	10.36	OD 62
210+1°1	M 1-8	S	55	12.37	1	...	...
212+4°1	M 1-9	S	28	11.68	1	12.08	P 71
		T	19	11.64	1	...	...
215–24°1	IC 418	S	55	9.62*	2	9.57	CD 60
						9.53	OD 62
						9.71	P 71
						9.52	K 76
215+3°1	NGC 2346	S	92	11.27	1	11.33	KAC 76
221–12°1	IIC 2165	T	54	10.90	1	10.85	P 71
						10.99	K 76
						10.90	TPP 77
						10.89	KoM 81
226–3°1	PB 1	T	27	12.02	1	12.01	P 71
228+5°1	M 1-17	T	19	12.23	1	11.87	P 71
232–4°1	M 1-11	S	37	11.68:	1	11.85	K 83
		T	27	11.65	1	11.97	P 71
232-1°1	M 1-13	T	19	11.67	1	11.60	P 71
						11.85	K 83
234+ 2°1	NGC 2440	S	74	10.49	4	10.56	OD 63
		T	54	10.50	1	10.40	P 71
						10.54	K 76
						10.48	TPP 77
239+13°1	NGC 2610	S	55	11.35*	2	11.38	OD 63
						11.37	P 71
						11.42	K 76
240–7°1	M 3-2	T	27	12.32	1	...	...
241– 7°1	M 4-1	S	55	12.03	1	...	...
242–11°1	M 3-1	S	74	11.27:	1	11.37	P 71
254+8°1	M 3-6	S	37	10.78	1	...	...
261+2°1	He 2-15	T	27	11.58	1	...	...
261+8°1	NGC 2818	T	54	11.44	1	11.40	OD 63
						11.24	P 71
261+32°1	NGC 3242	S	74	9.82	6	9.74	P 71
		T	54	9.78	3	9.83	K 76
265+4°1	NGC 2792	T	54	11.31	1	11.23	P 71
						11.39	AF 64
272+12°1	NGC 3132	T	54	10.36	1	10.37	W 69
						10.49	P 71
294+4°1	NGC 3918	T	54	10.05	1	10.01	W 69
						9.97	P 71
						10.03	TPP 77
						10.04	KoM 81
326+42°1	IC 972	S	92	12.04	3	...	...
337+16°1	NGC 5873	S	28	11.12	2	11.06	W 69
						11.02	P 71
						11.08	KoM 81
341+13°1	NGC 6026	S	92	11.61	1	...	...
342+27°1	Me 2-1	S	28	11.41	2	11.30	P 71
						11.39	K 76
						11.35	KoM 81
						11.31	K 83

* Exciting star's contribution has been subtracted.

AD 75: Adams (1975); AF 64: Aller and Faulkner (1964); ALi 68: Aller and Liller (1968); B 78: Barker (1978); CD 60: Capriotti and Daub (1960); K 76: Kaler (1976); K 83: Kaler (1983); KAC 76: Kaler, Aller and Czyzak (1976); KoM 81: Kohoutek and Martin (1981); Li 55: Liller (1955); OD 62: O'Dell (1962); OD 63: O'Dell (1963);P 71: Perek (1971); TPP 77: Torres-Peimbert and Peimbert (1977); W 69: Webster (1969).

sense that our measurements yield brighter nebulae. This effect is mainly due to the fact that NGC 2440 and IC 289 are, respectively, 0.07 and 0.05 brighter in log F(Hβ) that the value given by O'Dell. However, our result for NGC 2440 is in good agreement with that by Torres-Peimbert and Peimbert (1977). Figure 1 is a plot of the differences between the logarithmic Hβ fluxes in common with other authors,

$$\Delta = \log F(H\beta)_{\rm others} - \log F(H\beta)_{\rm us} \quad ,$$

versus our measurements, wherever the number of objects in common is three or larger. From the figure and from Table 4, it is noticeable that for the objects in common with O'Dell (1963), Capriotti and Daub (1960), Webster (1969), Barker (1978), Torres-Peimbert and Peimbert (1977), and Kohoutek and Martin (1981), the standard error in our measurements is between 10 and 15%. However, for the objects in common with Perek (1971), and Kaler (1976,1983), the standard error is between 30 and 50%. It must be concluded that the fluxes obtained by the latter authors are to be taken with caution. Although the origin of these discrepancies is unknown, aperture effects and offsetting errors can not be ruled out in Kaler's measurements. Considering as high quality measurements those of the former authors, we note that, out of a total of 55 planetary nebulae reported here, 15 had no previous Hβ integrated fluxes and 17 had non-reliable measurements.

This is Contribution No. 112 of Instituto de Astronomía, UNAM.

TABLE 3

NEBULAR AND TOTAL FLUXES FOR OBJECTS IN WHICH THE CONTRIBUTION OF THE CENTRAL STAR IS IMPORTANT

	– log F(Hβ)	
Object	Nebula	Total Flux
NGC 40	10.37	10.33
IC 289	11.63	11.60
NGC 1985	12.20	12.00
H 3-75	12.25	11.95
NGC 2392	10.29	10.17
NGC 1535	10.44	10.40
IC 418	9.62	9.50
NGC 2610	11.35	11.24

TABLE 4

COMPARISON BETWEEN PRESENT FLUXES, LOG F(Hβ), AND PREVIOUS OBSERVATIONS

Author[a]	N	Zero Point	Dispersion
B 78	7	– 0.034	0.06
CD 60	5	+ 0.008	0.04
K 76	8	– 0.052	0.09
K 83	11	– 0.099	0.13
KoM 81	5	+ 0.024	0.02
OD 63	7	– 0.016	0.04
P 71	17	+ 0.013	0.17

a. As in Table 2.

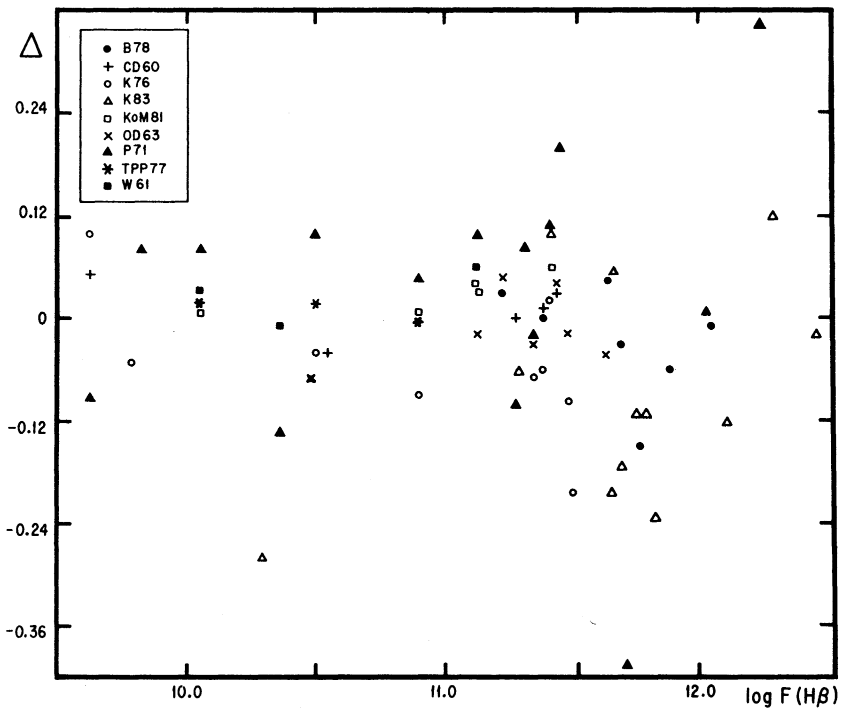

Fig. 1. Differences between the logarithmic Hβ fluxes published by other authors and those given in the present paper (see text). Reference to specific authors as in Table 2.

REFERENCES

Adams, T.F. 1975, *Ap. J.*, **202**, 114.

Aller, L.H. and Faulkner, D.J. 1964, in *The Galaxy and the Magellanic Clouds, IAU Symposium No. 20*, eds. Kerr and Rodgers (Canberra: Australian Academy Sci.).

Aller, L.H. and Liller, W. 1968, in *Stars and Stellar Systems*, eds. Middlehurst and Aller (Chicago: The University of Chicago Press), Vol. **VII**, p. 483.

Barker, T. 1978, *Ap. J.*, **219**, 914.

Capriotti, E.R. and Daub, C.T. 1960, *Ap. J.*, **132**, 677.

Code, A.D. 1960, in *Stellar Atmospheres*, ed. J.L. Greenstein (Chicago: The University of Chicago Press), p. 50.

Hayes, D.S. and Latham, D.W. 1975, *Ap. J.*, **197**, 593.

Kaler, J.B. 1976, *Ap. J.*, **210**, 113.

Kaler, J.B. 1983, *Ap. J.*, **264**, 594.

Kaler, J.B., Aller, L.H., and Czyzak, S.J. 1976, *Ap. J.*, **203**, 636.

Kohoutek, L. and Martin, W. 1981, *Astr. and Ap. Suppl.*, **44**, 325.

Liller, W. 1955, *Ap. J.*, **112**, 140.

O'Dell, C.R. 1962, *Ap. J.*, **135**, 371.

O'Dell, C.R. 1963, *Ap. J.*, **138**, 239.

Perek, L. 1971, *Bull. Astr. Inst. Czechoslovakia*, **22**, 103.

Torres-Peimbert, S. and Peimbert, M. 1977, *Rev. Mexicana Astron. Astrof.*, **2**, 181.

Webster, B.L. 1969, *M.N.R.A.S.*, **143**, 79.

Luis Carrasco, Rafael Costero, and Alfonso Serrano: Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D.F., México.