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Spectroscopic observations of faint and misclassified planetary nebulae (*)

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Summary. — Using low resolution IDS spectra, we try to clarify the classification of 264 objects which appeared as planetary nebulae in various listings, and were originally included in two lists of Sanduleak (1976) : (1) misclassified or doubtfully classified planetary nebulae ; (2) faint, suspected planetary nebulae. The new data show that 67 % of the objects can be considered as « true » planetary nebulae, of which 46 % present low excitation characteristics. The status of the other objects remains quite uncertain, some of them being symbiotic stars (14 %), or various emission-line objects. In 4 cases, we found no positive indication of emission-line objects in the observed areas.

Key words : planetary nebulae : classification — emission-line objects.

The set of planetary nebulae (PN), late stages in the evolution of stars of intermediate mass, is remarkably heterogeneous, showing a large variety of shapes and spectra. It is therefore possible to mistake some of them for objects showing morphological or spectroscopical similarities in connection with similar physical processes, but having quite different origin, mass, etc...

Since 1984, we have conducted a spectroscopic study of the whole system of planetary nebulae, with a double aim :

— realization of an atlas of calibrated spectra, within the framework of the new « Strasbourg — ESO catalogue of planetary nebulae » ;

— statistical study of spectroscopic properties of the PN in relation to problems on stellar evolution.

But the first aim of our work is to study as extensively as possible the true status of the just over 1500 objects which are presently called « PN ». The Catalogue of Galactic PN (CGPN) done by Perek and Kohoutek in 1967 gave the compilation of 1036 PN ; new PN are listed by Kohoutek (1977, 1983) and by Acker *et al.* (1984). Lists of misclassified objects have also appeared, showing that the material may be quite inhomogeneous.

In the present paper, we examine, through our own spectroscopic observations alone, a set of 264 PN taken from the CGPN, and listed by Sanduleak (1976) in his table I : « misclassified and doubtfully classified planetary nebulae », and table II : « faint, suspected planetary

nebulae ». A paper II (by Acker *et al.*) will present a general review of all PN given as misclassified or doubtful in the literature, including those studied here. In a paper III, we will give the lines intensities and the $I(\lambda)$ recordings of the objects classified as true or possible PN.

1. Observations.

The spectra were obtained in 1984 April, 1985 July-August, and 1986 January, with the Image Dissector Scanner (IDS) device, mounted on a conventional Boller and Chivens spectrograph on the 1.52 m telescope at the European Southern Observatory (ESO), La Silla ; details about the measurement procedure may be found in papers by Lundström and Stenholm (1984), and Stenholm (1986). The spectrum, taken at low-resolution (1 pixel = about 0.2 nm), covers a range from about 400 to about 725 nm. The aperture used is 4" × 4", well adapted for most of the objects studied here, showing small extension.

Depending on the large number of objects, the exposure time for each object must be short. We have chosen a standard exposure time of 10 min for all objects, instead of adjusting it to the brightness of the nebula. The noisiness of the resulting spectrogram then gives indirectly a measure of the faintness of the object.

Reductions and measurements were performed with the aid of the Image Handling And Processing programme (IHAP) of ESO, at Garching and at Strasbourg (using the HP 1000 computer of the « Institut de Physique du Globe »).

(*) Based on observations collected at the European Southern Observatory, La Silla, Chile.

2. Results.

Table I shows the following data, for 264 objects listed in order of their increasing galactic longitude :

2.1 NAME. — The PK number defined by Perek and Kohoutek (1967) in the CGPN ;

— the current number given by Sanduleak (1976) in his table I (objects called M1 to M179) and table II (F1 to F153) ;

— the usual name, given under the PK number.

2.2 NATURE OF THE OBJECT. — It is very difficult to define the true nature of an object. According to previous studies (Chopin et al. 1976 ; Sanduleak and Stephenson, 1973 ; Allen, 1978, 1984), we have adopted spectroscopic criteria related with the degree of excitation of the nebular spectrum. A PN is characterized by a high excitation, generally revealed by a high value of the ratio $I([\text{OIII}] 495.9 + 500.7)/I(\text{H}\beta)$. We have chosen the following rather empirical classification :

(1) The class PN is given for the objects showing $I([\text{OIII}])/I(\text{H}\beta) \geq 4$; for a value ≈ 7 of this ratio, the high excitation line HeII 468.6 should generally appear.

— H : means a very high excitation, shown by $I([\text{OIII}])/I(\text{H}\beta) \geq 15$, and

$$I(\text{HeII } 468.6)/I(\text{H}\beta) \geq 0.5,$$

or $I([\text{OIII}] 436.3)/I(\text{H}\gamma) \geq 1$.

— ℓ : means a low excitation, corresponding to $I([\text{OIII}])/I(\text{H}\beta) = 1$ to 4, and $I(\text{HeII}) = 0$.

— VLE : means a very low excitation, corresponding to $I([\text{OIII}])/I(\text{H}\beta) \approx 0$ to 1, $I(\text{HeII}) = 0$, and $I([\text{NII}])/I(\text{H}\alpha) \approx 1$; the object should be either an HII region, or else a VLE PN.

— pos. PN ? : in this class of objects, we include as possible PN the VLE nebulae with $I([\text{OIII}]) = I(\text{HeII}) = 0$, $I([\text{NII}])/I(\text{H}\alpha) \approx 1$, and exhibiting a fairly strong [SII] doublet, allowing in many cases the deduction of a high density (« hd ») for the nebulae. Considering other observations of these nebulae, it appears that they show properties typical of PN, in particular in the IR range (Pottasch, 1986, and Paper II).

(2) no PN : means ratios

$$I([\text{OIII}])/I(\text{H}\beta) = I(\text{HeII})/I(\text{H}\beta) = 0$$

or invisible, and $I([\text{NII}])/I(\text{H}\alpha) < 1$ (in most cases H α only visible). But in some cases, these ratios can be of higher values, the spectrum showing elsewhere characteristics of another kind of object (symbiotic star, for example). The status « no PN ? » is given in these cases, and also in cases where the [OIII] and HeII lines are not detected (noted inv., 0, or 0 ?) and where the [NII] doublet intensity is comparable to that of H α , the [SII] lines being very faint or invisible.

— The class « symbiotic star » is given for objects showing a red continuum with the TiO absorption bands ; high ionized lines, such as HeII, [CaVII], [FeVI], [FeVII], and the characteristic (unidentified)

683 nm (and sometimes 709) emission feature (see Allen, 1984).

— In most cases, we give no precision about the nature. The object can be an HII region, or an emission-line star, or a reflection nebulae, ...

— If no emission features are discovered around the theoretical position, it is noted that we have « no positive indication of emission lines-objects in this area », depending on bad or wrong finding charts, or misclassification problems.

(3) For some objects, we give other precisions :

— X : corresponds to steep Balmer decrements probably due to reddening ; the ratio H α /H β is high (≥ 25) and higher order Balmer lines are not detected (following the classification of Sanduleak and Stephenson, 1973).

— hd : means « high density », deduced from a high ratio of the [SII] doublet : 673.1/671.7.

— Spectral peculiarities are noted ; in particular, the estimation of the ratio [OIII] 436.3/H γ is given, when this ratio is ≥ 1 .

2.3 DESCRIPTION OF THE SPECTRUM. — Three ratios of line intensities are estimated :

$$[\text{OIII}] (495.9 + 500.7) / \text{H}\beta ;$$

$$[\text{NII}] (654.8 + 658.3) / \text{H}\alpha ,$$

and HeII (468.6)/H β . The following comments are given, to allow the distinction between the different classes discussed above :

0 : means that the line l_1 is not detected in the ratio l_1/l_2 ; in the case of the blend [NII] + H α , we

note : « H α only », if [NII] is invisible ;

inv. : means that the two (or three) lines are undetected ;

$\geq x$: means that the ratio is higher than $2x$;

$\leq x$: means that the ratio is lower than $x/2$;

? : means that the detection is doubtful, near the limit of the resolution. In particular, the [OIII] doublet seems in some cases blended with near HeI, FeII lines.

It should be noted that, in the case of surface objects, the ratios depend from the distance to the center (in the case of 331-01¹, two different estimations are given).

— Qualitative indications are done for the *continuum*, according to the mean level of the flux ϕ (calculated in $10^{-18} \text{ W/m}^2/\text{nm}$) :

strong : corresponds to $\phi > 1000$;

faint : $\phi = 25$ to 300 ;

very faint : $\phi < 25$.

The mean color of the continuum is also given. The observed *absorption features* are indicated, especially the red bands of TiO.

2.4 FINDING CHART. — The last column of table I concerns the appearance of the objects in the sky ; for most of them, the aspect is small, starlike ; but 39 nebulae present an extended morphology.

A number of faint objects listed in the CGPN are

difficult to identify on the finding chart (FC); in 35 cases, the FC is incorrect or unclear in the CGPN, the objects having only been seen as a faint speck on an objective prism plate, or as a hardly visible shadow on a Palomar Sky Survey copy. In the forthcoming « Strasbourg-ESO catalogue », we will give the true position of the objects, identified on ESO sky survey plates for the southern ones. In five cases, no emission-line objects have been found; these are probably merely plate faults.

3. Comments and conclusions.

The statistical analysis of our results shows the following distribution (Tab. II). Most of the objects considered by Sanduleak as misclassified (M) in his table I are of uncertain status, or definitely not PN; regarding his table II of faint (F) suspected PN, we can support his conclusion that most of them are true PN. Analysing the whole sample of 264 objects, we see that 67 % of them in fact show spectral characteristics of planetary nebulae; 32 % are PN with « normal » excitation, but showing in many cases spectral peculiarities, 4 % are PN of high excitation, and 31 % show low excitation; it must be noted that about 20 objects of low or very low excitation show strong lines of [OIII] 436, and may perhaps represent young or proto-planetary nebulae, like IC 4997? (see Sanduleak and Stephenson, 1972).

The status of many objects still remains uncertain. Spectroscopic criteria are not sufficient to permit the discrimination. In the forthcoming paper II, we will try to clarify the classification, using all published observations (morphological, radio, IR, ...). In particular, good IRAS measurements (Pottasch, 1986) indicate PN colours for the 9 objects classified as « no PN? » in our table I and noted by an asterisk; most of these objects show a strong Balmer-decrement, due to high reddening.

Let us consider here two particularly well represented classes of objects: the « VLE » nebulae, and the symbiotic stars.

About 21 % of the objects are listed as « VLE ». The VLE class was suggested by Sanduleak and Stephenson (1972, 1973) as being a class of nebulae which have a low [OIII]/H β value and high [NII]/H α value. It is, however, not possible to distinguish the VLE objects from PN. In particular, Stenholm (1986) and Sabbadin *et al.* (1986) show that there is no obvious correlation between these two line ratios. VLE objects can be early stages of PN when the central star's temperature reaches about 2 to 3×10^4 K, giving low excitation on the nebular gases; the objects seem generally characterized by a high density (noted « hd »).

A relatively high proportion (14 % of which 9 % are definitive) of *symbiotic stars* are identified; many of them are not present in the catalogue of Allen (1984), and will be dealt with in a special paper by Lundström and Stenholm. It is not clear if being a symbiotic star precludes it from being a PN. In particular, the following objects show spectral characteristics on the two classes: $6 + 2^2$, $7 + 1^2$, $23 - 1^1$, $280 - 2^1$, $325 + 4^2$, $346 + 8^1$, $351 + 3^1$, and especially $2 - 3^4$ and $312 - 2^1$. It is possible that in general many of the objects called PN on the basis of visual low resolution observations show, especially in the red part of their spectrum, characteristics of symbiotic stars. Thus it is very hard to specify what is the set of observed quantities which really and definitely can describe a planetary nebulae.

Acknowledgements.

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TABLE I.

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART
		[OIII] H β	[NII] H γ	HeII H δ	Contin. absorp.				[OIII] H β	[NII] H γ	HeII H δ	Contin. absorp.	
000+04 1 H97 M 2-11	PN ; X	≈ 1	0			001-02 1 F105 H 2-34	no PN ; X symbiotic star HeI, [FeVII], 683 emiss.	0	He only	0	very faint, red + abs. (F107)		
000+03 1 F64 R 2-250	PN	> 1	> 1		Extended object	001-03 1 M131 H 1-47	posPN ? hd	0	1	0			
000-00 1 F74 B 3-4	no PN ?	inv.	inv.		FC unclear very faint object	001-03 2 M133 Ap 1-7							
000-00 2 M119 B 3-22	no positive indication of emiss. line object in this area			Faint + absorpt. (A-F st?)									
000-01 3 F90 B 3-0	posPN ? hd strong [SII]	0	0		FC unclear	001-04 1 M143 H 1-55	PN ? VLE ; hd	< 1	≈ 1	0			
000-01 5 F88 M 2-19	PN ? 4	> 1	0		Extended object	001-06 1 M158 CMy 17	no PN/symbiotic or emiss. star ? strong [OIII] 436 , HeI emiss.	< 1	He only	< 1	rather red +abs. (F10)		
000-02 1 F94 B 3-13	PN	> 1	0	very faint	FC unclear	002-01 1 M115 H 2-20	PN ? VLE ; hd	< 1	> 1	0 ?			
000-02 3 F98 H 2-32	no PN [OII] 732-3 emiss.	0	< 1	very faint									
000-02 5 F100 M 3-47	PN	≈ 1	> 1			002-01 1 F106 Pe 2-11	PN	> 1	> 1	0			
000-02 6 F103 M 3-19	PN	≈ 1	< 1	very faint, red		002-02 3 F110 Pe 2-12	posPN ? hd	0	> 1	0			
000-04 3 F117 B 3-117	PN	≈ 1	0			002-03 1 M137 Ap 1-8	no PN/Symbiotic star? [FeVII], HeI emiss.	< 1	He ≈ 1		faint, red + abs. (F10)		
000-05 1 F120 H 2-40	PN	S7	0			002-03 3 M138 M 1-37	posPN ? hd	0	≈ 1	0			
001-02 1 F68 M 2-262	PN	> 1	< 1		FC unclear								
001-01 1 F69 X 1-4	PN ; hd	24	> 1		Extended object	002-03 4 M140 H 2-38	PN/Symbiotic star? [OIII] 436 >H γ , HeI, [OI], [FeVII], 709 and strong 683 emiss.	24	He only	≈ 5			
001+00 1 M117 B 3-2	no PN	inv.	inv.	faint, red	FC unclear	002-03 5 M141 M 1-38	posPN ? hd	0	S1	0			FC unclear
001-00 1 M120 B 3-11	no PN ; peculiar Multiple emiss. lines strong HeI, FeII, [FeII] [OI],....	0	0	strong, red +abs.	FC and α, δ Incorrect	002-05 1 M157 H 2-370	no PN? symbiotic star? [FeVII], HeI emiss.	≈ 1	He only		red +abs. (F10)		FC Incorrect
001-01 1 F89 B 3-8	PN ? VLE ; X [Ar III] emiss.	≈ 1	0		FC and α, δ Incorrect	003+05 1 M103 H 2-15	PN	> 1	> 1	0			
001-01 2 F91 B 3-9	PN ; hd ; X	> 1	0			003+03 1 M108 H 2-17	posPN ? [SII] emiss.	0	≈ 1	0			
001-01 3 F95 H 2-31	posPN ? hd ; X [SII] emiss.	inv.	inv.		FC unclear	003-01 1 M132 M 2-235	no PN ; X	inv.	He only	inv.	rather, red +abs.		

TABLE I (continued).

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART
		[O III] H β	[N II] H α	He II H β	Contin. absorp.				[O III] H β	[N II] H α	He II H β	Contin. absorp.	
003-02 2 F113 M 2-26	PN	>7	\approx 1	\approx 1		005-05 2 M163 He 2-390	no PN? peculiar Multiple Fe II, [Fe II], [OI], [O II], [S II] emiss.	<1	<<1	0			
003-04 1 M149 Ap 1-10	no PN; symbiotic star He I, He II, [Cav II], [Fe VII], and strong 683 emiss.	<1	He only	S1	red +abs. (TiO)	005-08 1 F135 Hf 2-2	PN ? /	>1	<<1	0			Extended object
003-04 2 M148 Ap 1-9	no PN? emiss. star? strong He I emiss.	<1	He 0?	only	red +abs. (TiO)	006+07 1 M102 M 1-21	no PN; symbiotic star He I, He II, [Cav II], [Fe VII], 683 emiss.	0	He only	\approx .5	red +abs. (TiO)		
003-04 6 M150 Ap 1-11	no PN; symbiotic star He I, He II, [Cav II], [Fe VII], 683 emiss.	0	He only	\approx .5	faint, red +abs. (TiO)	006+03 1 F75 H 2-22	no PN ?	0	\geq 1	0?			
003-04 7 M151 Ap 1-12	posPN ? hd	0	\approx 1	0	faint, blue (B-star)	006+03 2 F76 M 1-28	PN	>7	>>1	0			Extended object
003-04 9 M154 H 2-43	PN? peculiar [O III] 436 \approx Hy	>1	He only	\approx .2		006+02 1 F78 Th 4-3	posPN ? hd	0	S1	0			
004+06 2 M100 H 1-24	PN	>4	<<1	0		006+02 2 M124 H 2-28	no PN ? X; symbiotic star ? He I, He II, [Cav II], [Fe VII], [OI], 709, and strong 683 emiss.	>1	He only	\approx .5			
004+02 1 M122 H 2-25	PN ? VLE	S1	<1	0	very faint, red +TiO abs. ?	006-02 1 M146 M 1-41	PN	>7	>>1	0			Extended object
004+01 1 F77 H 2-24	PN	>4	<1	0		006-03 1 M153 H 1-61	PN ? /	\approx 4	\approx 1	0?			
004-02 1 M139 H 1-53	PN; peculiar	>4	\approx 1	0	+abs. (G-K star)	006-04 1 F129 Pe 2-13	PN / H	>>7	<<1	\approx 1			
004-04 2 M160 M 1-44	posPN ? hd	0	\approx 1	0		007+04 1 F73 Th 4-1	PN ? / ; peculiar [O III] 436 \approx Hy, He I emiss.	>1	He only	0	red +abs. (TiO)		
004-05 2 F126 He 2-376	no PN? emiss. star? strong He I emiss.	<1	He only	0	red +abs. (TiO)	007+01 2 M128 M 3-18	no PN; symbiotic star He I, He II, [Cav II], [Fe VII], 683 emiss.	0	He only	\approx .5	red +abs. (TiO)		
004-05 5 F131 M 2-37	PN ? VLE	\approx 1	<1	0	very faint	007-03 1 F127 M 2-34	PN	\approx 7	\approx 1	\approx .2			Extended object
005+06 1 F66 M 3-11	PN ? VLE	S1	<1	0	Extended object	007-04 1 M162 H 1-65	posPN ? hd	0	\approx 1	0	faint, rather blue		
005+04 2 M111 M 3-13	PN? / X	\approx 4	<<1	0		008+06 1 M106 He 2-260	no PN ? hd ?	0	<1	0	faint, blue		
005+03 1 F71 Pe 1-9	PN / hd	S4	<<1	0	FC unclear	008+05 1 F72 Th 4-2	PN	\approx 7	<1	\approx .5			
005+02 1 M121 H 1-34	PN ? /	>1	\approx 1	0	FC unclear	008+03 2 M123 Th 4-4	no PN? symbiotic star? strong [O III] 436 and un? faint 683 emiss	\approx 1	He only	0			
005-04 1 F124 M 2-44	PN / H	>>7	He only	\approx 1	very faint, red								

TABLE I (continued).

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		[OIII] H β	[NII] H α	HeII H β	Contin. absorp.				[OIII] H β	[NII] H α	HeII H β	Contin. absorp.	
008-03 1 F130 H 1-64	PN ? λ	\approx 1	\approx 1	0		019+00 1 F132 M 3-53	PN; hd ; X	\gg 7	\gg 1	0		Extended object	
008-06 1 M169 H 2-47	no PN ; X	0	Ha only	0		021-00 1 F136 M 3-28	PN ; X	\gg 7	\gg 1	\approx 2		Extended object	
009-02 1 M159 He 2-374	no PN; symbiotic star [OIII] λ 36, HeI, HeII, faint 683 emiss.	\leq 1	Ha only	\approx 3 red. +abs. (T10)		021-00 2 F136 M 3-55	PN	\approx 7	\gg 1	0		Extended object	
010+18 2 M62 M 2-9	PN ? λ	21	\approx 1	0		021-01 1 M171 M 1-51	PN ; X WC feature (doubl. [CIV] near 580)	\approx 7	\gg 1	0		Extended object	
010+03 1 F99 Th 4-10	PN ; hd	\approx 4	\approx 1	0		023-01 1 F142 K 3-9	PN? X; symbiotic star HeI, HeII, [FeVII], 683 emiss.	54	\approx 0	\approx 6	very faint, red +abs. (T10)		
010-03 1 M166 He 2-396	no positive indication of emiss. lines-object in this area					023-01 2 F144 K 3-11	pos:PN ? hd ; X [SII] emiss.	0	\approx 1	0			
011+02 1 M130 Th 4-11	PN ? λ	21	\ll 1	0		024+05 1 F125 M 4-9	PN	\gg 7	\approx 1	0		Extended object	
011-00 1 F122 M 1-43	PN ; X	\gg 7	\ll 1	0	very faint	024+03 1 M164 M 2-40	PN ? λ	54	\ll 1	0	very faint, red		
011-06 1 M172 M 1-55	pos:PN ? hd	0	\approx 1	0	faint, blue	024+02 1 F146 M 2-46	PN ? VLB	\ll 1	\gg 1	0	very faint, red		
011-09 1 M175 M 2-48	PN ? λ ; hd	\approx 1	\ll 1	0	faint, rather blue	024-03 1 F147 Pe 1-17	PN ; H	\gg 7	\gg 1	\approx 7			
012-02 1 M165 M 1-45	pos:PN ? hd	0	\approx 1	0		025-02 1 F145 Pe 1-15	PN	\gg 7	\ll 1	0	very faint, rather red		
012-07 1 M173 He 2-417	no PN; symbiotic star HeII, HeI, strong 683 emiss.	0	Ha only	\approx 7 red +abs. (T10)		026+01 1 F139 V-V 1-8	no PN ? X	inv. \approx 1	inv.	inv.		Extended object	
015+03 1 M145 M 1-39	PN ? VLB ; hd ; X	51	\gg 1	0		026-02 2 M176 K 4-7	no PN; symbiotic star HeI, HeII, [FeVII], 683 emiss.	0	Ha only	21	faint, red +abs. (T10)		
016-01 1 M168 M 1-46	PN? VLB WR feature near HeII 468.5	51	\ll 1	07	faint, blue	027+04 1 F133 M 2-43	PN ; X [OII] 732 -3 very strong	\gg 7	\ll 1	0			
017-04 1 F143 M 3-30	PN	\gg 7	\ll 1	\approx 7	faint, red	027+00 1 F141 M 2-45	PN ; hd ; X	\gg 7	\ll 1	0		Extended object ?	
018+03 1 F123 M 4-8	no PN ; X strong [OII] 732 -3	inv.	\ll 1	inv.		027-02 1 F148 Pe 1-18	PN ; hd ; X	\gg 7	\ll 1	0			
018-01 1 M170 M 1-49	no positive indication of emiss. lines-object in this area				F-star ?	028+05 1 M167 K 3-2	PN ? λ ; X [OII] 732 -3. emiss.	21	\approx 1	0			
018-02 1 F137 M 3-54	PN ; H	\gg 7	Ha only	\approx 5		028+02 1 F140 K 3-7	PN ; X	\gg 7	Ha only	07			

TABLE I (continued).

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART
		[O III] Hp	[N II] H α	He II Hp	Contin. absorp.				[O III] Hp	[N II] H α	He II Hp	Contin. absorp.	
028-02 1 F149 Sa 3-149	no PN ; X	0	H α only	0		266-01 1 M11 Ve 27	no PN ; peculiar Multiple emiss. lines	0	<<1	0			
028-03 1 F150 Pe 1-21	PN ; H	>7	H α only	\approx 1		274+02 1 M16 He 2-34	PN ; peculiar strong [O III] 436	>4	<<1	0	faint, red	FC incorrect	
029-02 1 M178 Pe 2-16	no PN ; symbiotic star He II, He I, faint [Fe VII] and 683 emiss.	>1	H α only	\approx 7		275-03 1 M14 He 2-25	PN ; peculiar very strong [O III] 436 (> 3 H γ)	>7	H α only	0		FC incorrect	
031-01 1 M174 PC 20	PN	>7	\geq 1	0		278-04 1 F9 He 2-32	PN	>>7	>>1	0		Extended object	
032-03 1 F152 K 3-18	no PN ; X very strong [O II] 732-3	0 ?	<<1	0		280-02 1 M18 H 2-38	no PN ? symbiotic star [O III] 436, H γ , [O I], He I, He II, [C IV], Fe [VI], [Fe VII], 683 emiss.	>1	H α only	\approx 3	faint, red +abs. (TiO)		
032-03 2 F153 K 3-20	PN ? VLE ; hd	<1	\approx 1	0	very faint, red	283-01 1 F12 Hf 4	PN	>>7	>>1	vis?		Extended object	
033-04 1 M179 K 4-17	no PN ; X	inv.	H α inv.	only		285-02 1 M20 He 2-47	PN ? VLE ; hd VR feature near He II 468.5	<1	\geq 1	07	faint, rather blue		
211-03 1 F1 M 1-6	PN ? λ	>1	<1	0		288+05 1 M26 He 2-61	no positive indication of emiss. line object in this area	<1	\approx 1	0		Extended object	
232-04 1 M1 M 1-11	PN ? VLE ; hd	<1	\approx 1	0	faint, rather red	289-01 1 F13 He 2-57	PN	\approx 4	<<1	0		Extended object	
234-00 1 M3 M 1-15	no PN	0	H α only	0	faint.	291+03 1 M27 He 2-64	PN ? VLE	<1	\approx 1	0			
235-03 1 M2 M 1-12	PN ? VLE ; hd	<1	\geq 1	0	faint, rather blue	294-04 1 M28 II 2621	PN ? λ	>1	\geq 1	0		FC unclear	
240-07 1 F2 M 3-1	PN	>4	>>1	\approx 9		296-06 1 M30 He 2-71	PN ? λ	\geq 1	<1	0			
241-07 1 F3 M 4-1	no PN ; galaxy $\Delta\lambda/\lambda \approx 0.006$	>>7	>1	\approx 2	faint, rather red	297+03 1 F17 He 2-78	PN ? VLE	<1	\geq 1	0			
248-08 1 M6 He 2-10	no PN ; galaxy $\Delta\lambda/\lambda \approx 0.003$	>1	<1	0	faint, rather blue	298-00 1 F16 He 2-77	PN ; X	>7	<<1	0		Extended object ?	
259+00 1 M9 He 2-15	PN ; X	>>7	<<1	07		298-01 2 F15 He 2-76	PN ; H	>>7	>>1	\approx 5		Extended object ?	
263+00 1 M10 K 2-15	PN ? λ	S4	<<1	0		299+02 1 F19 He 2-82	PN	>>7	\geq 1	\approx 3		Extended object ?	
266+02 1 M13 Pe 2-3	no positive indication of emiss. lines-object in this area		strong red +abs. (TiO) (M st.?)			299-00 1 M32 He 2-80	no PN ; X Strong [O I] 630	0	H α only	0	faint, rather red +abs.	Extended object ?	
266+00 1 F8 Ve 22	no PN ; X	0	H α only	red		299-01 1 F18 He 2-81	PN	>>7	>>1	0			

TABLE I (continued).

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART
		[OIII] H β	[NII] H α	HeII H β	Contin. absorp.				[OIII] H β	[NII] H α	HeII H β	Contin. absorp.	
300+00 1 F21 He 2-83	PN ? VLE ; hd ; X	>1	0	0		FC unclear	322-00 1 F28 Fe 2-8	PN ; X ; hd strong [ArIII]	>>>	<<1	0		
302-00 1 M34 He 2-87	no PN ; X HeI emiss.	inv.	He only	very faint, red +abs. (TiO?)	Extended object ?		323-02 1 F30 He 2-132	PN	>	<<1	\approx .5		
305-00 1 M35 He 2-91	no PN ; X	0	He only	faint, red			324+02 1 F29 He 2-125	posPN ? [SII] emiss.	0	>1	0		
308-12 1 F24 Sa 3-24	PN	>4	He only	faint, blue	FC and α, δ incorrect		324-01 1 F31 He 2-133	PN ; X ; hd	>>>	<<1	0?		
309-04 1 F23 H 2-99	PN ? VLE ; Multiple WC emiss. lines(WC9 central star)	0?	>>1	faint, blue			325+04 2 M48 He 2-127	PN ? ; symbiotic star ? [OIII] 436, HeI, HeII, [CIV], [FeVII], [OI], strong 683 emiss.	>1	He only	\approx .5	faint ?	
311+03 1 M38 He 2-101	PN? ; peculiar [OIII] 436 \approx Hy, HeI emiss.	>1	He only				326-01 1 M52 He 2-139	no PN	0	He only	0	faint, red +abs. (TiO)	
312-01 1 F26 He 2-107	PN? VLE	51	>1	very faint, red			326-06 1 M60 He 2-151	posPN ? hd ?	0	<<1	0	faint, blue	
312-02 1 M42 He 2-106	PN; symbiotic star [OIII] 436 >H γ , HeI, HeII, [OI], [CIV], [FeVII], 709, strong 683 emiss.	>4	<<1	\approx .3 faint, red +abs. (TiO)			326-10 1 M75 Cn 1-2	no PN; symbiotic star [OIII] 436, HeI, HeII, [CIV], [FeVII], 683, 709 emiss.	<<1	He only	\approx .7	strong red abs. (TiO)	
315+09 1 M41 He 2-104	PN; peculiar, variable? [OIII] 436 \approx Hy ; strong HeI emiss.	\approx 4	<<1	\approx .2 very faint, red			327-01 2 M54 He 2-140	PN ? VLE ; hd	<<1	>1	0		
315-13 1 M49 He 2-131	PN? VLE ; hd WR feature near HeII 468.5	<<1	>1	blue (O-star?)			327-02 1 M56 He 2-142	PN ? VLE WR feature near HeII 468.5 and 570	\approx 0	>1	0		
316+08 1 M43 He 2-108	PN ? ; WR feature near HeII 468.5	>1	<<1	\approx .1 faint, blue (O-star?)			327-04 1 M59 He 2-147	PN; H; peculiar [OIII] 436 >H γ , HeI, HeII, [OI] emiss.	>>>	>1	0	Faint, red +abs. (TiO)	
318-02 2 F27 He 2-116	PN	>7	>1	0	Extended object		328-17 1 M114 He 2-269	no PN ; galaxy $\Delta\lambda/\lambda \approx 0.0015$	>7	<<1	0?		
319-09 1 M50 He 2-134	no PN; symbiotic star Faint [OIII] 436, HeI, HeII, [CIV], [FeVI], [FeVII], 683 emiss.	0	He only	red +abs. (TiO)			330+04 1 M51 Cn 1-1	PN; H; peculiar [OIII] 436 \approx SH γ ; HeI emiss.	>>>	<<1	0?	cont. +abs.	
320-09 1 M53 He 2-138	posPN ? hd	0	>1	blue			331+00 1 F34 He 2-145	PN ; X	>>>	>>1	0?		
321+03 1 M45 He 2-113	PN ? VLE; peculiar Multiple emiss. lines (HeI, CIV, CIV strong [ArIV],...)	-0	<<1	rather blue			331-01 1 M61 Mz 3	PN ? VLE ; hd	<<1	>1	0		
							331-02 1 M64 He 2-157	PN ? ;	>1	<<1	0		

TABLE I (continued).

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART								
		[O III] H β	[N II] H α	He II H β	Contin. absorp.				[O III] H β	[N II] H α	He II H β	Contin. absorp.									
331-03 1 M66 He 2-162	PN ? VLE	<<1	\approx 1	0	faint, blue	Extended object	344-08 1 M109 PC 18	no PN? symbiotic or peculiar star ? [OIII]436, NIII, HeI, HeII, CIII ? emiss.	\approx 1	He only	\approx 0.1	red +abs. (TiO)	Extended object								
331-05 1 M71 PC 11	PN; H; peculiar [OIII]436 >H γ , HeI emiss.	>>7	<<1	0			345+04 1 M76 Vd 1-2	posPN ? Hd ? [OII]732-3 strong	0	<<1	0	inv.		Extended object							
334+00 1 M65 Fe 2-9	no PN; X	inv.	He only	inv.	faint, red		345-00 1 M84 H 2-3	no PN; X [ArIII] emiss.	inv.	<1	inv.				Extended object						
335-01 1 F36 He 2-169	PN; peculiar [OIII]436 strong ?	>4	>>1	0			345-08 1 M112 Tc 1	PN ? ℓ	>1	<<1	0	blue				Extended object					
336+01 1 F35 Fe 1-6	PN	>7	<<1	0			346+08 1 M69 He 2-171	PN? symbiotic star ? [OIII]436 >H γ ; HeI, HeII, [CavII], [FevII], [OI], 683 emiss.	\leq 4	<<1	\approx 6						Extended object				
337+01 1 M67 Fe 1-7	no PN ? WR feature (CIII,CIV...)	0	>1	<<1	faint, red		348-00 1 M89 H 2-5	PN ? ℓ ; X [OII] 732-3 emiss.	>1	<1	0							diffuse object FC, a, δ slightly wrong			
337-05 1 M79 He 2-187	PN + bright central star ?	>4	He only	0	strong, blue (O-B star)		349-03 1 F62 H 2-14	PN	>7	He only	\approx 1								Extended object		
338+05 2 M63 He 2-156	no PN FeII, HeI emiss.	0	He only	0	red +abs. (TiO)		350+04 1 M81 H 2-1	PN ? VLE	\approx 1	<1	0									Extended object	
338-01 1 M72 He 2-174	no PN; X	0	He only	0	faint, rather red +abs.		351+05 1 M80 M 2-5	PN ? VLE	<1	>1	0										Extended object
339+00 1 M73 He 2-176	no PN; X; symbiotic star ?	<1	He only	0?	faint, red		351+03 1 M83 H 2-2	no PN? symbiotic star [OIII]436, HeI, HeII [CavII], [FevII], strong 683 emiss.	<1	He only	\approx 1	red +abs. (TiO)									
339+00 2 M74 He 2-179	no PN; X emiss.-line star ?	inv.	He only	inv.	red +abs.	351-04 1 F70 H 2-19	no PN ? Faint HeI, FeII emiss. lines	0?	He only	0	faint, red +abs. (TiO)	Extended object ?									
341-00 1 M78 He 2-183	no PN; X	0?	He only	?		351-05 1 M113 He 2-275	no PN; symbiotic star HeI, HeII, 683 emiss.	0	He only	\approx 1.5	red +abs. (TiO)		Extended object ?								
342+05 1 M70 He 2-173	no PN? symbiotic or He star ? [OIII] 436 >H γ , HeI, HeII emiss.	>1	He only	\approx 0.3	red +abs. (TiO)	352+03 1 M86 H 2-4	no PN? symbiotic star [OIII]436, HeI, HeII [CavII], [FevII], faint 683 emiss.	<1	He only	\approx 1	very faint, red			Extended object ?							
342+00 1 F38 H 1-3	PN	>7	>>1	0		352+00 1 F51 H 1-12	PN; X	>>7	<<1	0?					Extended object ?						
344+03 1 F37 Vd 1-3	PN ? ℓ	>1	<1	0		352-00 1 F55 H 1-13	PN; X	>>7	<<1	0						Extended object ?					
344+00 1 F39 H 1-5	PN; X; Hd strong [ArIII] emiss.	>7	<1	0		353-05 1 F81 H 1-36	PN	\approx 7	>>1	0							Extended object ?				
344-01 1 F40 H 1-6	PN	>7	>>1	0		354+04 1 M87 M 2-10	PN ? ℓ	>1	\approx 1	0								Extended object ?			

TABLE I (continued).

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART
		[OIII] HP	[NII] He	HeI HP	Contin. absorp.				[OIII] HP	[NII] He	HeI HP	Contin. absorp.	
354+04 2 M88 H 2-5	no PN; symbiotic star HeI, HeII, strong 683 emiss.	0	He only	≈.7	faint, red +abs. (T10)	FC unclear	357+03 3 F54 Th 3-17	no PN; emiss. star? HeI emiss.	≤1	He only	07	faint, red +abs. (T10)	
354+03 1 F44 Th 3-4	PN ; X	>>7	<1	0			357+03 4 F52 M 3-42	PN; H	>>7	>1	≈.5	very faint blue	
355+03 3 F45 Th 3-6	PN	≈4	≈1	0			357+03 5 F53 Th 3-16	no PN	0	<1	0	very faint, blue	
355+02 1 M90 Th 3-9	no PN ? X strong HeI emiss.	Inv.	<<1	Inv.		FC unclear	357+02 3 M96 Th 3-20	no PN; symbiotic star HeI, HeII, [CavIII], [FeVII], 683 ? emiss.	<1	He only	≈.1	faint, red +abs. (T10)	FC unclear
355+02 2 F48 Th 3-10	PN ; X	>7	≈1	07		FC unclear	357+02 5 F56 M 4-4	PN	>>7	≤1	07		FC unclear
356+05 1 F42 Th 3-3	PN	≈7	≈1	0			357+02 6 F59 H 2-13	PN ; hd	>>7	<<1	≈.1		Extended object?
356+03 1 F49 Th 3-12	PN ? VLE	<1	>1	0			357-03 1 M125 He 2-294	no PN; symbiotic star HeI, HeII, strong 683 emiss.	0	He only	≈.5	faint, red +abs. (T10)	
356+02 1 M93 Th 3-13	PN ; X	>7	<<1	0			357-03 3 F87 H 2-29	PN ? VLE	≈1	≈1	0		
356+01 2 F58 Th 3-55	PN ; X	≤7	<<1	0			357-04 3 M129 H 1-43	poaPN ? hd	0	≈1	0		FC incorrect
356-02 2 M118 M 1-27	poaPN ? hd	0	≈1	0			358+05 2 F46 M 3-40	no PN	0	≈1	0		
356-03 1 F79 H 2-26	PN	>4	>>1	07			358+04 1 M92 M 3-8	PN ; hd	≥7	<1	0	very faint, red	
356-03 2 F83 H 2-27	PN ; hd	>7	≈1	0			358+03 4 M98 H 1-19	PN	<7	≥1	0		FC unclear
356-03 3 M127 H 1-39	PN ? VLE	<<1	≤1	0			358+03 5 M95 Th 3-18	no PN; symbiotic star HeI, HeII, strong 683 emiss.	0	He only	≈.6	faint, red +abs. (T10)	
356-05 1 F109 H 2-35	PN	>7	≤1	≈.5			358+03 8 F60 Th 3-26	PN ; H	>>7	<1	≈.6		Extended object?
356-06 1 F112 M 3-49	PN	>7	>>1	0		Extended object	358+02 3 F61 Th 3-29	no PN; symbiotic star? HeI, faint 683 emiss.	<<1	He only	07	faint, red +abs. (T10)	FC unclear
356-06 2 F116 H 1-51	PN	>7	≈1	07		Extended object?	358+01 1 F65 M 4-6	PN ; X	>>7	<<1	0		Extended object?
356-07 1 M144 He 2-349	no PN; emiss. star? HeI, FeII emiss.	<<1	He only	red +abs. (T10)			358+01 2 M101 Th 3-31	no PN ? emiss. star? X HeI emiss.	07	He only	0	faint, red +abs. (T10)	
356-07 2 F121 H 1-57	PN	≈7	≈1	0			358+01 3 M104 H 1-25	no PN; symbiotic star? ≈.1? HeI, strong 683 emiss.	>>7	He only	07	faint, red +abs. (T10)	Extended object?
357+03 2 M94 M 3-41	poaPN ? hd	0	≈1	0									

TABLE I (continued).

NAME	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART	FINDING CHART	NATURE OF THE OBJECT	DESCRIPTION OF THE SPECTRUM				FINDING CHART
		[O III] H β	[N II] H α	He II H β	Contin. absorp.				[O III] H β	[N II] H α	He II H β	Contin. absorp.	
358-00 2 M116 M 1-26	PN ? VLE [O III] 732-3 very strong	≤ 1	< 1	0									
358-02 2 F85 B 3-6	no PN; X symbiotic star He I, He II, strong 683 emiss.	0	He only	≈ 0.8	faint, red tabs. (TiO)								
358-03 1 F101 M 1-44	PN ? 4	> 1	> 1	0									
358-05 2 M135 M 1-49	no PN; peculiar He I, [O I], Fe I, [Fe II], ... emiss.	0 ?	He only	0	faint.								
358-05 4 F118 M 3-51	PN	> 7	> 1	0									
358-06 1 M147 He 2-354	no PN WC feature near 465 and 580, strong He I emiss.	≈ 0	He only	≈ 0.6	rather blue								
358+05 1 M91 M 2-12	poPN ? hd	0	≈ 1	0	very faint, blue								
358+04 1 F50 Th 3-14	poPN ? hd strong [S II] emiss.	0	< 1	0	faint, rather red								
358-03 2 F57 Th 3-25	PN very faint	> 4	He only	0									
358+02 1 F63 Th 3-30	no PN; X symbiotic star He I, He II, 683 emiss.	0	He only	≈ 0.5	faint, red tabs. (TiO)								
358+02 3 F67 Th 3-33	no PN ? X [Ar III] emiss.	0	> 1	0									
358-01 2 F82 M 3-44	poPN ? X strong [S II] emiss.	0	≈ 1	0									
358-01 3 F84 M 3-45	PN	> 7	< 1	≈ 0.3									
358-02 1 F86 B 4 L	no PN ; X	inv.	He only	inv.									
358-02 4 F93 M 3-46	PN	> 4	> 1	0									
358-03 1 F97 M 3-17	PN ? ; hd	≥ 1	< 1	0									
358-03 2 F102 M 2-33	PN	> 7	He only	≈ 1									
358-04 1 F108 M 3-48	PN	> 7	> 1	0									

⊙ Probably PN, taken into account other observations (in particular, good IRAS measurements indicating planetary nebulae colors at the correct position; Pottasch, 1988)

FC unclear
Extended object

[O III] H β > 7
[N II] H α only
He II H β ≈ 0.7
Contin. absorp.

[O III] H β 0
[N II] H α ≈ 1
He II H β 0
faint,
rather blue

FC and α, δ incorrect

Extended object ?

FC unclear

Extended object

TABLE II. — Classification of 264 objects from Sanduleak's « Misclassified or doubtfully classified PN » (137 objects M) and « Faint and Suspected PN » (127 objects F).

	PN	PN? ℓ	possible VLE PN		no PN			no indication of emiss. object
			PN ? VLE	pos. PN ?	no PN?	sybiot.st.	others	
Objects M	12%	14%	15%	12%	12%	14% (+9%?)	13%	14%
Objects F	63%	6%	8%	6%	7%	3% (+1%?)	6%	0%
all 264 objects	36%	10%	12%	9%	9%	9% (+5%?)	10%	2%