Perek: No, it does not change. This point is illustrated by the slide showing the distribution of angular diameters.

Westerlund: Henize and I have photographed with the 74-inch telescope at Mount Stromlo 165 southern objects out of a list of 283, half of which are new. It will be followed up, we hope, with Hβ photometry and spectroscopy. We hope to publish identification charts (in Hα) of all objects. I think the compilation of a general catalogue a very good idea.

Thackeray: Is it possible that there is a very strong observational selection whereby one loses many planetaries at distances greater than, say, 8 kpc?

Perek: If the distance scale is correct, we observe only a few planetaries at a distance greater than 8 kpc. A search for still fainter and smaller planetaries, carried out with a long-focus Schmidt camera and in excellent seeing, would be necessary to settle the question.

11. SPECTROPHOTOMETRY OF 14 SOUTHERN PLANETARY NEBULAE

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The theory of radiative and collisional processes in gaseous nebulae makes possible precise predictions of line and continuum intensities as functions of density, electron temperature, and degree of ionization of the emitting gases. It predicts, for example, the relative intensities of successive members of the Balmer series (Balmer decrement), and of corresponding transitions in the Balmer and Paschen series. Hence accurate line intensity measurements are not only of astrophysical interest; they also serve to assess the amount of space absorption.

Spectrophotometry may be done either photographically or photoelectrically. As far as isolated strong lines are concerned there is little question that the photoelectric technique is the more advantageous. For weaker lines, or for certain close pairs such as 3968 [NeIII], 3970 H, or 3726, 3729 [OII], high resolution, such as can be attained only by photographic techniques, is necessary.

In 1956 at the Mount Wilson Observatory, Liller and Aller used a photoelectric spectrophotometer designed and built by the former (Liller 1957) at the University of Michigan, to measure the relative intensities of stronger lines in northern planetary nebulae. The present program constitutes an extension of this work to the southern hemisphere, except that we were unable to secure observations in the red and infrared.

This scanner is supplied with slots and diaphragms of different sizes to accommodate objects of various angular diameters and to obtain spectral resolutions ranging from better than 24 Å up to 100 Å. Scanning speeds ranging from 30 Å/min to 270 Å/min were available. Since the instrument was originally designed for an $f/5$ system and had to be used on telescopes with aperture ratios of $f/12$ and $f/18$, it was necessary to add auxiliary optics in the entrance beam.

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We employed the low spectral resolution wide slot combination for measurements of the strongest lines such as Hβ or Hγ+4363, when it was necessary to insure that emission from the entire nebula was measured. Most southern planetaries are rather faint. Even among the brighter ones we have chosen, many are so faint that only the strongest lines could be measured with the widest slots.

Figure 1 shows tracings of a typical planetary NGC 2867. Generally, the green nebular lines are so much stronger than other lines in the spectrum that it is necessary to observe them with a different gain. To separate close lines such as λ4363 and λ4340, we used narrower slots such as the so-called B-slots which give a resolution of 24 Å.

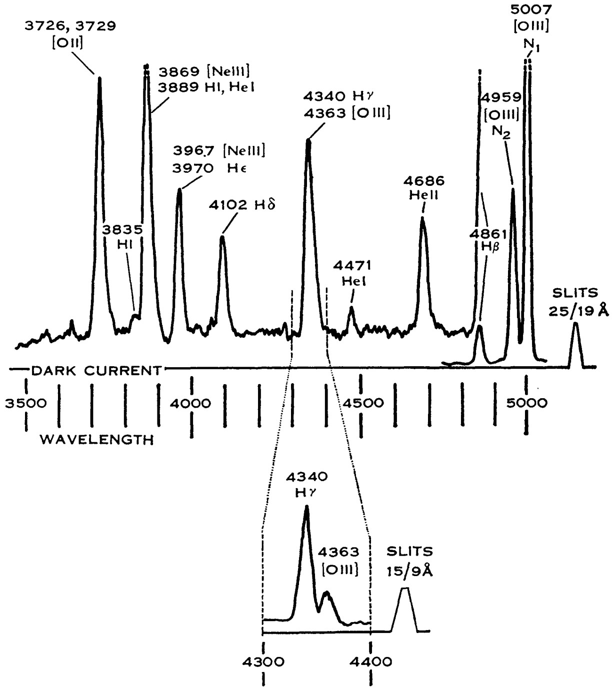

Fig. 1.—Scanner observation of the planetary nebula NGC 2867, made on the Mount Stromlo 50-inch reflector.

We observed both nebulae and suitable comparison stars on the same nights. The latter were scanned, as far as possible, both at high and low altitudes in order to establish atmospheric extinction. We actually found it practicable to use a mean extinction curve, based on several nights' work, rather than values obtained for individual nights. We selected our comparison stars from a group of objects which also served as southern spectrophotometric standards. A separate spectrophotometric program largely carried out at Mount Bingar involved the comparison of selected southern stars with northern standards established by Oke (1960) and by Code (1960). With the energy distributions of the southern comparison stars established, one can determine the wavelength dependence of cell sensitivity and instrumental transmissions.

TABLE 1

LINE INTENSITIES IN SOUTHERN PLANETARY NEBULAE

λ (Å)		IC 2448	NGC 2792	NGC 2867	NGC 3132	NGC 3195	NGC 3211	11h 27m	NGC 3918	NGC 5307	IC 4406	15h 30m	NGC 6153	IC 4642	NGC 6326
3340	[NeV]+OIII						3·2		2·71					5·5	
3425+40	[NeV]+OIII						7·3		6·0					17	
3727	[OII]	0·92	2·6	8·6	42	27	3·2	3·1	6·2	2·4	65	19·8	1·2	4·6	9·3
3750	H								0·3[3]						
3770	H								0·4[3]						
3797	H			0·4					0·6						
3835	H			0·6					0·9						
3868	[NeIII]	10·6	6·1	9·6	16·0	6·8	8·3	7·4	10·7	8·9	10·8	8·8	5·0	6·7	8·8
3889	H, NeI								2·0						
3970	H, [NeIII]	3·7	2·7	3·1	4·0	2·0	2·9	2·9	4·5	3·3	3·2	2·3	2·1	2·9	3·4
4026	HeI			0·2					0·2:						
4068	[SII]			0·4	0·8				0·5						
4101	H	2·4	2·2	2·4	2·3	2·9	2·4	3·2	2·8	2·1	2·5	2·6	2·4	4·1	4·1
4340	H	4·2	} 5·1	4·1	3·3	3·5	4·3	} 4·65	4·6	} 5·4	} 4·0	} 5·1	} 4·4	4·7	} 6·7
4363	[OIII]	1·4		1·0	0·5	0·5	1·7		1·8					2·3	
4471	HeI	0·4	0·8	0·4					0·48	0·5:	0·57:		0·4:		
4541	HeII			0·35					0·8						
4640	NIII						0·7								
4686	HeII	3·3	8·7	3·2	2·7:	2·0	7·5		4·9	2·6	0·5	2·7	2·3	14·2	3·4
4712	[AIV]	} 0·58	} 1·4	} 0·4			} 1·34		0·95					} 2·27	
4740	[AIV]								1·12						
4861	Hβ	10·0	10	10	10	10	10	10	10	10	10	10	10	10	10
4959	[OIII]	39	40	48	33	17·6	53	25	54	40	32	} 102	29	20	} 153
5007	[OIII]	121	122	147	102	55	165	76	166	123	100		89	60	

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Tracings of both nebulae and comparison stars in direct (i.e. wavelength increasing with time) and in reverse directions permitted us to evaluate the performance of the equipment and to detect any change in the condition of the sky.

Since the magnitudes and colours of the comparison stars are known, we can compare the fluxes of appropriate monochromatic nebular radiations with those from the stars at the same wavelengths to get the emission in CGS units. That is, we can determine the monochromatic emission from a particular nebula in $H\beta$ or $H\gamma+4363$ in ergs cm^{-2} sec^{-1} $(steradian)^{-1}$ if the angular size of the nebula is known. Since the relative nebular line intensities have been measured, all emission intensities can then be calibrated in surface brightness units, if one desires.

TABLE 2

FURTHER DATA ON 14 SOUTHERN PLANETARY NEBULAE*

Object	Surface Brightness	Adopted Radius (″)	$\frac{N_1+N_2}{H\beta}$	$\frac{N_1+N_2}{4363}$	Approx. Electron Temp. (°K)	$\frac{4686}{H\beta}$	$\frac{3727}{N_1+N_2}$
IC 2448	0·0127	4	16	114	13,000	0·33	0·0058
NGC 2792	0·0013	6·5	16·2			0·87	0·016
NGC 2867	0·0098	6	19·5	187	10,800	0·32	0·044
NGC 3132	0·00155	34·5	13·5	260	9,800	0·3:	0·32
NGC 3195	0·00033	19·3	7·26	142	11,900	0·2	0·37
NGC 3211	0·0028	7	21·8	128	12,500	0·75	0·0145
11^h 27^m	0·0022	8	10·1			0·1?	0·030
NGC 3918			22·0	122	12,700	0·49	0·028
NGC 5307	0·0024	6·3	16·3			0·26	0·015
IC 4406	0·0025	10	13·2			0·05	0·49
15^h 30^m			10·2			0·27	0·19
NGC 6153	0·0013	12·3	11·8			0·23	0·01
IC 4642	0·00087	8·3	8·05	35	23,000	1·42	0·06
NGC 6326	0·00233	6·8	15·3			0·34	0·06

* No correction for absorption has been applied, since its adequate evaluation requires further observations, particularly the relative intensities of Balmer and Paschen lines. The influence of space absorption would be to increase surface brightness, electron temperature, and the $\lambda3727/(N_1+N_2)$ ratio.

The observational results are summarized in Tables 1 and 2. For each line whose intensity has been measured, Table 1 gives the wavelength, identification, and intensity on the scale $I(H\beta)=10$ for the 14 far southern planetary nebulae measured in our program. As described earlier, some lines are blended. The weaker lines are uncertain; particularly dubious values are indicated by a (:). Furthermore, the accuracy of the far ultraviolet lines $\lambda3340$, $\lambda3425+\lambda3440$, is adversely affected by large atmospheric extinction. Not all nebulae were observed to the same degree of completeness. Some were so faint as to permit measurement of only the strongest lines with the widest slots. The final values given in Table 1 had to be calculated by comparing scans with different speeds, amplifications, and purities (slot widths).

Although the entire nebula fell in the slot in low resolution scans, those of high resolution often entailed selection of a portion of a bright ring or shell, i.e. a strip across the nebula.

Table 2 gives further data for these planetary nebulae. The surface brightness is given in ergs cm^{-2} sec^{-1} $(steradian)^{-1}$ for Hβ, on the basis of the adopted radius given in the third column. The fourth column gives the ratio of the green nebular lines to Hβ. It ranges from 7 to 22 and is small both for very low excitation nebulae and for very high excitation nebulae. The intensity ratio of the green nebular lines to λ4363 depends primarily on the electron temperature (Menzel, Aller, and Hebb 1941; Liller and Aller 1954; Seaton 1960) although it also becomes small in nebulae with high densities. The approximate electron temperature ranges from 9800 to 13,000 °K except for the high excitation, low surface brightness nebula IC 4642 which appears to have an electron temperature in the neighbourhood of 23,000 °K. This is one of the highest-excitation nebulae known; the ratio 4686/Hβ is 1·4 and the ultraviolet [NeV] 3340, 3428 lines are strong. The only planetary known with a comparable [NeV]/Hβ ratio is Anon 21^h 31^m (Aller 1951).

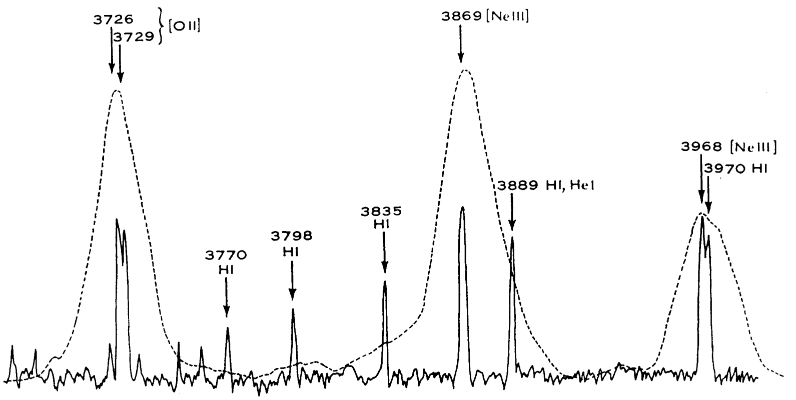

Fig. 2.—Comparison of a scanner observation with the microphotometer trace of a coudé plate for NGC 2867.

The last column gives the $3727/(N_1+N_2)$ ratio which is only roughly correlated with the level of excitation. The [OII] λ3727 pair tends to be weak in high excitation planetaries, except some of low surface brightness such as NGC 6720 which shows marked stratification.

Although virtually all of the nebulae examined appear to show λ4686 we cannot be sure that it is necessarily of nebular origin. In some instances it may arise in a central star. Likewise "λ4640" may arise from a central star.

The basic limitation of photoelectric scanning is that, although strong lines can be measured with high accuracy, poor results are often obtained for weaker lines — partly because of blending and partly because of uncertainty in drawing in the continuous background on the tracings. Hence it is necessary to supplement spectral scans with spectrograms obtained with an ordinary spectrograph. Close blends can then be resolved and their relative contributions to individual lines

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on the scans can be assessed. Thus by combining photographic and photoelectric data a fairly accurate set of nebular line intensities can be obtained (see Fig. 2). Unfortunately we have not found it possible to secure the necessary supplementary spectrograms.

The southern hemisphere contains many fainter planetaries, but their effective observation would entail a much more extended program.

Among the objects we have observed, IC 4642 clearly deserves much more detailed study. Also NGC 3211, 2867, 2792, and 3918 would merit closer examination with adequate spectrographic equipment.

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12. THE SCORPIO–CENTAURUS ASSOCIATION

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I. Introduction

The Scorpio–Centaurus association extends from about $l^{II}=356°$, $b^{II}=+20°$ towards lower longitudes over about 90° of the southern sky. Between $l^{II}=312$ and 356° it is located between latitudes +10 and +25°, and appears well detached from the more distant B-star population at lower latitudes. At longitudes below 312° it approaches and crosses the galactic plane and is seen projected against the general low latitude B-star population from which it is more difficult to separate. These features are clearly brought out by Figures 5 and 6 of the author's thesis (1946) and had been recognized earlier by others (e.g. Kapteyn 1914).

The association is part of the general population of early-type stars in the region within 500 pc which forms the subsystem usually referred to as the Local