GENERAL DISCUSSION – SEVENTH SESSION

Seaton: I think it would be useful to summarize the estimates which have been made for the calibration of Shklovsky's distance scale for optically thin nebulae. Table 1 gives: the calibration constant, relative to O'Dell's value; the nebular mass, including helium; the mean distance, $|\bar{Z}|$, from the plane. (The table was completed by contributions from other participants.)

Table 1

Author	Calibration Constant	M_{neb}	$\lvert\bar{Z}\rvert$	Remarks
O'Dell	1·00	0·2	280	
Seaton	1·45	0·6	360	method valid for $0{\cdot}06 \leqslant R \leqslant 0{\cdot}6$, where R is the nebular radius in parsecs
Šklovsky	0·63	–	–	
Abell	0·8	–	–	
Webster	–	0·2	–	
Oort	–	–	340–450	From $\lvert\dot{Z}\rvert = 18$–24 km sec^{-1}

Perek: From what year is the value by Oort of $|\dot{Z}| = 18$ km/sec?

Seaton (to Perek): It is the value quoted at the Vatican Conference in 1957.

Perek: Then it was before the radial velocities by Minkowski and Mayall were known. I get from planetaries above 20° latitude a value of 24 km/sec.

Seaton: I would like to report on the conclusions reached in a private discussion between O'Dell, Perek, Cahn and myself, concerning space densities. Let χ be the number of planetaries evolving per cubic parsec per year in the local region. The following results have been obtained (Table 2), assuming in all cases an expansion velocity of 20 km/sec^{-1}.

Table 2

Author	$\chi \times 10^{13}$	Adopted distance scale
O'Dell	3·9	O'Dell
Cahn	4·6	Seaton
Cahn	15	O'Dell

When the same distance scale is used, Cahn's value of χ is several times larger than O'Dell's. Cahn fits the data to an assumed galactic distribution while O'Dell counts the number in a certain finite volume. Perek has deduced the density by counting numbers

Osterbrock and O'Dell (eds.), Planetary Nebulae, 467–469. © *I.A.U.*

in spheres of finite radius and extrapolating to zero radius. His results are in general agreement with those of Cahn.

Weidemann: I want to bring up the question of the planetary nebula mass again; how do we feel about it at the end of this meeting?

Abell: Most of the planetaries that I have investigated are at distances between 2 and 4 K_{pc}, because they are large and faint and would be hidden by extinction at larger distances. In general, due to the uncertainties in observational data and the uncertainties of the assumptions employed, I would not take seriously these differences in the distance scales.

As for the masses of typical shells, the very few independent determinations we have are obtained from measuring the flux from objects whose distances are assumed known from other kinds of observations. Because we suspect there to be unresolved filamentary structure, however, we really do not necessarily obtain the correct mass, but a function of mass and filling factor. The actual masses of the shells, in other words, could be much less than the values we generally assume.

O'Dell: The method used for optically thin nebulae shown in the review paper figure uses an average value for ε determined by the calibration independent of eye estimates and hence should not be greatly sensitive to unresolved filaments.

Weidemann (to Seaton):

(1) How would your mass change if you take the distance scale of O'Dell?

(2) How certain is your value in view of the fact that the best fit given in your publication was drawn in a rather compressed ordinate scale, 1 cm corresponding to a factor of 10?

Williams: I would like to point out that, assuming the validity of Seaton's mass vs. radius curve, the nebular mass one obtains for an assumed electron temperature of 10000 °K is 0·4 $M_{\odot}$, instead of 0·6 $M_{\odot}$.

Gurzadian: I have a comment in connection with the evolution of the nuclei. From the point of view of the evolution of central stars of the planetary nebulae, perhaps there should be some interest in the search for and investigation of stars which are former nuclei. Particularly, it is not unexpected that some part of the Humason-Zwicky blue objects in high galactic latitudes may be former nuclei of planetary nebulae.

Salpeter: I would like to give an oversimplified summary of the similarities and differences of some of the models we have heard about:

(1) The three sets of models by Savedoff and Van Horn, by Vila and by Beaudet and Salpeter essentially form one class of models. The essential feature of these models is an almost homogeneous star consisting mainly of C^{12} and slightly heavier nuclei. The exact abundance ratios of C-O-Ne-Mg, the numerical values used for reaction rates and opacity and the range of stellar masses considered varied somewhat, but the main conclusions are at least semiquantitatively the same: to obtain luminosities comparable with the observed ones, rather large masses are required for these homogeneous models, $\sim$1·0 to 1·2 $M_{\odot}$ (slightly larger if neutrino reactions are absent).

With neutrino reactions included, the evolutionary time-scales of the large-mass models are also of the right order of magnitude.

(2) The two sets of models by Rose and by Faulkner also form one class, a more realistic class of models which also contain a core of carbon (and oxygen, etc.) but are allowed a substantial helium-envelope in which helium burning can proceed. Again a range of masses was considered ($\sim 0{\cdot}6$ to $1{\cdot}0\ M_{\odot}$) and here slightly lower masses are sufficient to give the observed luminosities ($\lesssim 0{\cdot}8\ M_{\odot}$). The models of this class carried out so far show that thermal instabilities are likely to be important, but the precise kind and phase of instability to be encountered in central stars of planetary nebulae is not yet clear.

(3) Realistic models are not yet available for stars that have recently lost their outer layers dynamically (suddenly) and are in the process of relaxing from this mass ejection, but Deinzer's models may give some qualitative hints.