GENERAL DISCUSSION – FIRST SESSION

Salpeter: We have heard an estimate for the total number of planetary nebulae in the Galaxy of about 50000. I would like to know: (a) Allowing for selection effects, etc., what is the estimate of the total number of planetary nebulae in globular clusters? (b) Is there any positive evidence for planetary nebulae in young galactic clusters (or in a binary with a young star as companion)?

O'Dell: Only a single planetary is known in a globular cluster, this being K 648 in M 15. This object was studied and found to have a common velocity and heavy-element deficiency with the cluster, and there seems to be little question of cluster membership. Many years ago Baade searched several globular clusters and found no additional objects.

Several coincidences with galactic clusters are known, but in each case studied in detail, there is a significant difference of radial velocity so that no generic relationship is indicated.

Münch: In relation to O'Dell's remark, I wish to say that two years ago I photographed 7 of the nearer globular clusters through a 50 Å passband Hα filter with the 200-inch Palomar telescope. A careful blink procedure against comparison plates taken in a passband void of emission lines failed to reveal any other planetary than the one known in M 15. It should be remarked, however, that with the estimate of 50000 in the galactic system, one would expect only 5 planetaries among the 10^7 stars involved in these globular clusters. Thus, within the uncertainty of small-number statistics, there is agreement between the expected and observed number of planetaries in globular clusters.

Perek: Planetary nebulae belong to the disk population as defined by the Vatican conference in 1957.

Osterbrock: But could not say 10% of the planetaries be Population I?

Feast: There certainly seems to be good evidence from the kinematics of the galactic planetary nebulae for a considerable range in ages. The asymmetrical drift is quite small for the planetaries near the Sun, as is the velocity dispersion. The mean age of planetaries near the Sun cannot therefore be too large. However, the velocity dispersion and hence the inferred mean age increase as one goes in towards the galactic centre.

Underhill: Is there any observational information to support the hypothesis that planetary nebulae having central stars with a Wolf-Rayet spectrum are distributed as Population I objects, whereas those with central stars having a continuous spectrum are distributed with the Disk Population?

Osterbrock and O'Dell (eds.), Planetary Nebulae, 51–53. © *I.A.U.*

Aller: In surveying central stars of as many planetary nebulae as possible, only a small number of Wolf-Rayet nuclei were found. The statistics do not suffice to decide whether they do or do not tend to favor the galactic plane.

Feast: The one planetary in the Magellanic Clouds in which it has so far been possible to detect a WR nucleus (LMC Henize N 203) is one which shows a considerable deviation from the rotation curve. My results indicate that this object would be contained with the other LMC planetaries in a single gaussian distribution, though Westerlund and Webster prefer to treat it separately as being, presumably, more like Population II.

Minkowski: If the observed proper motion of expansion of a planetary nebula is interpreted under the assumption that the nebula is spherical, an incorrect distance may result. An example is NGC 2392, which is possibly a prolate ellipsoid seen end-on, and the observed radial velocity is therefore possibly significantly larger than the tangential velocity of expansion. Furthermore, in NGC 2392 the radial velocities over the North half of the nebula are systematically positive, and in the South half, systematically negative. This cannot result from spherically symmetric expansion.

Reeves: Does rotation play a role?

Minkowski: No, the angular momentum involved would be far too large. It must result from expansion that is not spherically symmetric.

Münch: In a statistical sense, however, the method of angular motions should provide a direct estimate of distances.

Minkowski: That is true, but it is important to realize that any individual distance can be incorrect by a factor of 2 as a result of this non-spherical expansion.

Mathews: As a matter of principle, even if a planetary had perfect spherical symmetry, there are still problems in interpreting the proper motion observations of the Lillers and others. The proper motion measurements refer to the apparent contractions or expansion of the outermost layers, while the radial-velocity measurements taken at the centre of the nebula, say, represent some mean value weighted over the entire nebula. In particular a rarefaction wave moving inward into an expanding spherical nebula can give the impression in the sky that the nebula is shrinking and yet the gas velocity is everywhere outward.

Seaton: Minkowski and others have calculated distances of optically thick nebulae assuming all central stars to have equal absolute magnitudes. This is useful for galactic distribution studies but not if one wants to consider the evolution of the central stars! I think that in the latter case the only method generally available is to use forbidden-line intensity ratios to get the electron density.

For galactic-structure studies it is of interest to know the total number of planetaries per unit volume, but for evolution studies it is more important to know the number of optically thin planetaries per unit volume per unit radius interval.

Savedoff: It is dangerous for a theorist to suggest observational problems. I remember, however, that an important contribution to the resolution of the uncertainty in Cepheid and RR Lyrae distance scale (1952) was the apparent increase in the width of the galactic plane with distance. If planetaries and white dwarfs are in fact evolutionarily connected, then we should require

(a) $\overline{|z|}_{\text{w.d.}} = \overline{|z|}_{\text{planetary}}$

(b) $\overline{z^2}_{\text{w.d.}} = \overline{z^2}_{\text{planetary}}$

(c) that $z_{\text{planetary}}$ be free of any heliocentric peculiarities.

I recognize that the comparisons may be difficult because of selection effects, particularly in the white-dwarf data.

Cahn: An important method of calibrating the distance scale of planetary nebulae would be to measure the angular sizes of planetaries in the Magellanic Clouds. Is this observation possible?

Westerlund: So far no planetary nebula in the Magellanic Clouds has been resolved. It should be possible to resolve fainter ones ($m \leqslant 20$ mag) using existing telescopes, but the attempts have not yet been successful. Very good seeing is required.

Menon: I would like to point out that the shape of the radio-frequency spectrum, which is quite sensitive to the presence of irregularities in the nebula, can be used to obtain information about the filling factor for those cases where the radio-frequency spectra are available.

Abell: We observe fine-scale filamentary structure in many nebulae. But can we not place a lower limit to the size of such filaments? Gas at 10^4 °K has a thermal velocity of about 10 km/sec, and we should not expect it to be able to maintain very small filaments (say, less than 10^{15} or 10^{16} cm across) for periods greater than 10^2 years, should we?

Osterbrock: Filaments are there whether we understand why they are or not. They may well overlap, and therefore we cannot tell the filling factor from examination of direct photographs.

Minkowski: Though individual filaments may dissipate quickly, if some mechanism continually generates new ones, then some will always be present.

Mathews: Since planetary nebula typically expand differentially at supersonic velocities, inhomogeneities expanding at about the velocity of sound may not smooth out.

Cahn: One lifetime of a condensation will be of order: (linear dimensions)/(speed of sound), whether the flow in the large is subsonic or supersonic. In either case the continued existence of fluctuations needs to be explained.

Seaton: In principle it is possible to obtain information about fine-scale filamentary structure from studies of two or more different ratios of forbidden-line intensities. Further observational work would be of value in this connection.