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A SURVEY OF PLANETARY NEBULAE NEAR THE GALACTIC CENTER*

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Due to strong interstellar absorption it has not been possible up to the present to determine the distribution of Population II objects near the galactic nucleus.

Because of their importance for the study of the dynamics of the nuclear region, and in particular for obtaining better data on the gravitational field, an attempt has been made to get information on the distribution of planetary nebulae near the center at radio wavelengths.

Although the investigation is still in progress it seemed fitting at the present occasion to give a brief outline of the program because of the essential place which Rudolf Minkowski has occupied in this field. His great survey of planetary nebulae (1946, 1947, 1948, 1951) provided the first reliable data on their distribution, and particularly on their very strong concentration to the center. Together with Mayall he made an equally fundamental contribution to the study of the motions of the planetary nebulae (Mayall and Minkowski, unpublished) and provided the first clear evidence for the very high velocity dispersion of the nebulae within about 5° from the center (Minkowski 1965). From these data it is clear that the planetaries in this region belong to a pure Population II. From the 64 known radial veolcities of objects with longitudes and latitudes less than 5° we find a practically Gaussian distribution with a dispersion of 130 km s^{-1} (after a small correction has been applied for foreground nebulae). In this region there is no sign of galactic rotation (it is less than 20 km s^{-1}) which indicates that the velocity distribution may be nearly isotropic. At larger distances from the center the velocity dispersion decreases rapidly, and galactic rotation becomes prominent. Our discussion will be limited to the inner region.

Assuming a Maxwellian velocity distribution and a gravitational potential as derived from the rotation of the H I nuclear disk, combined with data on the distribution of the 2.2-μ radiation, the density is given by

$$\log \nu(R) - \log \nu(0) = -\mathrm{Mod}\ \{\Phi(R) - \Phi(0)\}\ disp^2 v_r \quad ,$$

where R is the distance from the center, ν the space density, v_r is the radial velocity in km s^{-1}, and Φ is the gravitational potential in (km $s^{-1})^2$. From the available data $\nu(R)$ was found to vary roughly as R^{-3} for $R > 80$ pc; for smaller R the variation becomes less steep (cf. Oort 1977). We want to compare the column densities corresponding to the space densities so obtained, with the observed surface densities; the ultimate aim being to use this comparison to get independent and improved data for Φ.

Surface densities $\sigma(r)$ were determined from the catalog of Perek and Kohoutek (1967). It is at once clear from a plot of the nebulae within 10° from the center how seriously the densities are affected by absorption; for instance there are almost no nebulae below 2° latitude. The only way in which one might hope to get reliable information on the densities within 5° from the center is by radio observations.

A systematic search is therefore being made with the Westerbork Synthesis Radio Telescope at 21 and 6 cm wavelength. It was found that about half of the known planetaries in the central region emitted sufficient continuum radiation to be observable, and that, consequently, the radio observations may make a significant contribution to our knowledge of the distribution of these objects in the region within 5° from the center. Because almost all of the planetary nebulae observed within $\sim 10°$ from the center must lie at the same distance they will at the same time provide valuable information about the radio luminosity function of planetaries. Unfortunately, however, the investigation is not yet sufficiently completed to report on the results.

Apart from the observational difficulties arising from their faintness and the proximity of the bright Sagittarius A source the search may be seriously hampered by (1) the difficulty of distinguishing between planetaries and compact H II regions in the central region, and (2) by the effect of the interstellar wind: with average velocities of 250 km s^{-1}, and at interstellar densities in excess of about 10 cm^{-3} most of the planetary shells would be blown away. According to Mezger (1974) such a density may exist within 10 or 15 pc from the center.

The importance of compact H II regions became evident in a field centered at $\ell = 0°.2$, $b = -0°.2$, within the extended ionized hydrogen region called the "arc" by the Bonn group (cf. Mezger 1974). The 6-cm observations at Westerbork, with a beamwidth of about 6″ in right ascension, show that the arc is

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full of unresolved H II regions. In size and radio spectrum these cannot be distinguished from planetary nebulae. The distinction can be made only from their distribution.

A very interesting new development which promises to provide data of the same kind as we were searching for in the planetaries has been the recent discovery by Baud, Habing, and others that type IIb OH masers in the central region probably share the dynamical characteristics of planetary nebulae, viz., a strong concentration toward the center combined with a very large velocity dispersion. These Population II masers can be identified without ambiguity, and their observation provides at once their radial velocity. As the space density of sufficiently strong OH masers of this type may be comparable to that of the planetaries they may ultimately provide an ideal tool for reaching the aims stated at the beginning of this report.

The following astronomers have taken part in the investigations reported: B. Baud, A. G. de Bruijn, E. Dekker, R. D. Ekers, W. Miller Goss, H. J. Habing, W. W. Shane, and J. G. A. Wouterloot.

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