Chemical Abundances and Metallicity of Planetary Nebulae

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Confrontations of the dredge-up theory with observed patterns of chemical abundances of planetary nebulae (PNs) have been carried out by many authors (see, e.g., Kaler & Jacoby 1990, 1991; Stasińska & Tylenda 1990). Although these studies suggest that the observational abundance ratios of PNs can qualitatively be explained by the current dredge-up theory, scatters around the theoretical predictions in their diagrams are always large. This has led Ratag (1991) to conclude that there is no correlation at all between the nebular abundances and the core mass of CSPNs (see also Pottasch 1993).

In this paper, we compare the core mass of the central stars of PNs (CSPNs), that is determined in a distance-independent manner (Zhang & Kwok 1993), with the abundances, [He/H], N/O, and C/O, taken from the literature. It is found that the theory is able to qualitatively give an outline about the chemical enrichment, but quantitatively, its predictions can only match the data in a rudimentary way.

When the Galactic distribution of CSPNs is investigated, it is found that while the CSPNs with a large core mass ($> 0.65 M_{\odot}$) heavily concentrate to the Galactic plane (within galactic latitudes $< 15°$), those of small core mass are spreading out of the plane up to $\approx 70°$. The lack of massive CSPNs is consistent with the lack of massive ordinary stars at high Galactic latitudes. This also indicates that the formation of PNs is hindered by the low metallicity at high Galactic latitudes.

At high latitudes, the O/H is as low as those lowest O/H values found for nebulae closer to the plane. Because the oxygen is not altered significantly during the stellar processing, this implies that the initial metallicity of the PN decreases with increasing distance from the plane. However, some CSPNs close to the plane also show low O/H abundance, where the ON processing of oxygen to nitrogen may have occurred in progenitor stars of greater mass and led to an oxygen depletion there.

The Galactic distribution of total CNO contents exhibits a relation that the total CNO abundance decreases with increasing latitude above the plane. In particular, all PNs with $|b^{II}| > 30°$ have their total CNO abundance below the mean value of 9.1. These high latitude PNs must have their progenitor stars being relatively metal-poor. However, closer to the plane the total CNO abundance exhibits a wide range from about 8.68 to as high as 10.

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