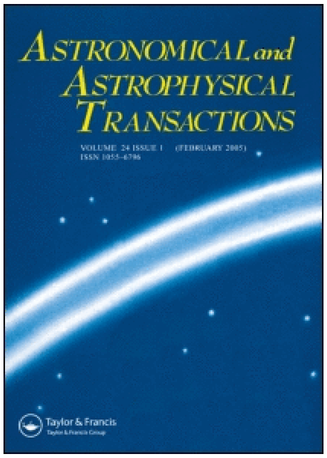

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THE STATE OF THE ART OF DISTANCES TO GALACTIC PLANETARY NEBULAE

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New methods of determining the distances to galactic planetary nebulae have been analyzed and various statistical distance scales have been compared.

KEY WORDS Planetary nebulae, distance scales

There are two approachs of solving the problem of distances for galactic planetary nebulae. The first one is a search for independent methods of individual distance determination. These methods are applicable for a small number of planetary nebulae. At present individual distances are determinated only for 110 nebulae. There are 296 distance estimations for them, 60% of values are obtained by the method of interstellar extinction. The second approach is a construction of statistical distance scales. The papers by B. A. Vorontsov–Velyaminov (1934) and I. S. Shklovsky (1956) have contributed significantly to the development of this trend. The constant-Hβ-flux- and the constant-ionized-mass-distance methods are sometimes applied nowdays (Kingsburgh and Barlow, 1992; Kingsburgh and English, 1992 [hereafter KBE]). The modern statistical scales are based, as a rule, on the empirical relationship between the nebula radius and the ionized mass (Daub, 1982; Chan, Kaler and Stanghellini, 1992 [hereafter CKS]), or between the nebula radius and the radio continuum surface brightness temperature at 5 GHz (Van de Steene and Zijlstra, 1995 [hereafter VdSZ]). Zhang (1995) employed both these relationships. A number of planetary nebula distance scales are based on using the central star parameters from theoretical evolutionary traces (Kaler, Mo and Pottasch, 1985; Mendez *et al.*, 1988; Zhang, 1993). In our paper (Sharova, 1995) a method of determining the distance to planetary nebulae has been based on the recently established (Sharova, 1992) regressional relationship between the central star radius and the temperature. The initial data for finding the distance are the nebula radio flux density and the stellar magnitude of the nucleus or one of these parameters and the central star temperature.

A comparison of our scale with 7 others appeared recently as well as with Shklovsky's classical scale has been done. The distances derived using various plan-

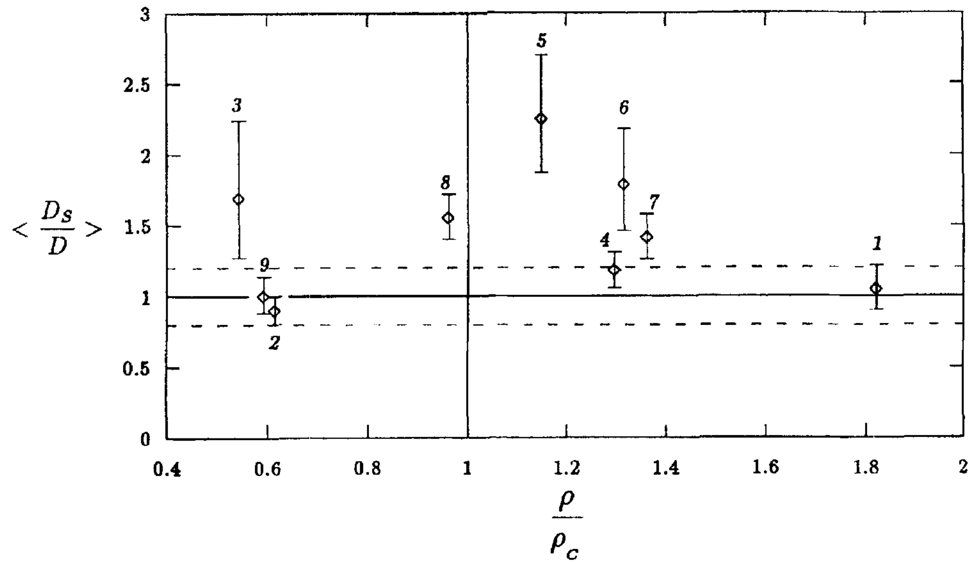

Figure 1 The comparison of distances derived using various planetary nebulae scales D_S with the individual distance D. The levels ±20% are marked by broken lines. The numbers indicate the distance scales: *1*, Shklovsky (1956); *2*, Daub (1982); *3*, Mendez *et al.* (1987); *4*, CKS (1992); *5*, KB (1992); *6*, Zhang (1993); *7*, VdSZ (1995); *8*, Zhang (1995); *9*, Sharova (1995).

etary nebula scales D_S are compared with the individual distance D obtained independently for the same nebula (Sabbadin, 1986). The values $\log(D_S/D)$ and their possible dependence on the radius of a nebula R_N are analyzed. In Figure 1 each scale is described by two parameters: an average value $\langle D_S/D \rangle$ with the confidence interval for the probability 90% and the relation ρ/ρ_c, where ρ is the correlation coefficient for $\log(D_S/D) - \log R_N$, and ρ_c – its critical value. In the range $\rho/\rho_c > 1$ the correlation is significant with the probability 0.999. The discrepancies of distance estimations are large enough. The largest distances are in the scale KBE. Only 4 scales give, on the average, deviations less than 20% of the individual distances: the scales by Shklovsky, Daub, CKS and ours. The Daub's scale gives small systematical underestimation of the distance unlike others. There is a correlation between the distance estimation and the radius of a nebula in scales by Shklovsky, Zhang (1993), VdSZ, CKS and KBE. In Shklovsky's scale it is the strongest. These scales overestimate the distance for a planetary nebula with the radius less than 0.1 pc and underestimate for a more extended one. Apparently only our scale and Daub's one agree satisfactorily, on the average, with the individual distances.

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