1990RMxAA..21..264D

Rev. Mexicana Astron. Astrof., **21**, 264-268 (1990)

DETERMINATION OF THE GALACTIC ROTATION CURVE BASED ON PLANETARY NEBULAE

Carlos M. Dutra
Walter J. Maciel

Departamento de Astronomia
Instituto Astronômico e Geofísico da USP

ABSTRACT: Planetary nebulae of types I, IIa, and IIb are considered in order to determine the galactic rotation curve. It is shown that the curves defined by the first two types do not differ substantially from the one derived on the basis of young population I objects, such as CO-H II molecular complexes.

RESUMO: Um grupo de nebulosas planetárias de tipos I, IIa, e IIb é utilizado para determinar a curva de rotação galática. Mostra-se que as curvas definidas pelos dois primeiros tipos de nebulosas não diferem substancialmente da curva obtida a partir de objetos jovens, de população I, como os complexos moleculares CO-H II.

Key words: GALAXY-STRUCTURE — NEBULAE-PLANETARY

I. INTRODUCTION

The rotation curve of our Galaxy is generally obtained from data of young objects in the galactic plane. However, comparison with data from older objects could bring additional information, especially regarding the dynamical history of the galactic disk.

A rotation curve based on planetary nebulae (PN) has been reported by Schneider and Terzian (1983) based on H I tangent point data, for the determination of the PN distance scale. The obtained curve is similar to the curve established from CO-H II region complexes, but with slightly lower velocities in the inner region of the Galaxy.

Planetary nebulae are originated from progenitors with distinct kinematics, age, mass, chemical composition and space distribution (see for example Maciel, 1989). Therefore, their use in galactic structure research requires a careful classification, where independent distance determinations are considered.

In the present work, preliminary results of a kinematical study of a sample containing 110 PN in the range $0.7 < R/Ro < 1.4$ are presented, in an effort to determine the rotation curve of our Galaxy. The nebulae are classified following Peimbert (1978), taking into account the subdivision proposed by Faúndez-Abans and Maciel (1987). The sample includes 32 type I objects (He- and N-rich), 64 type II (disk objects, 27 of type IIa, 32 of type IIb, and 5 unclassified), and 14 of type III (high velocities and heights from the galactic plane). We adopt the distance scale by Maciel and Pottasch (1980) and Maciel (1984), with some distances by Acker (1978) and Daub (1982). The radial velocities are taken from the compilation by Schneider et al. (1983).

II. SCHEME OF ANALYSIS

Given the radial velocity (V_{lsr}) of an object at distance d from the Sun in a direction of galactic coordinates l, b, the distance from the centre projected on the plane is given by

$$R = \{Ro^2 + (d \cos b)^2 - 2\, Ro\, d \cos b \cos l\}^{1/2} \qquad (1)$$

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..21..264D

The rotation velocity is

$$\Theta(R) = \{ \Theta_o + V_{lsr} / (\sin l \cos b)\} \; R/Ro \qquad (2)$$

and the height from the plane is simply

$$Z = d \sin b \qquad (3)$$

where Ro and Θ_o are the distance to the centre and circular velocity of the LSR, respectively. As a reference, we use the curves by Oliveira and Maciel (1986) and Clemens (1985), adopting Ro = 10 kpc and Θ_o = 250 km/s for convenience only, as we do not obtain significant discrepancies with different values for these parameters. Also, the difference between the curves is small, so that we will refer to them generically as "the rotation curve".

We define a deviation from the circular velocity for the PN by the difference between the rotation velocity inferred from the observed radial velocity (Θ_{pn}) and the velocity that the nebulae would have according to the adopted rotation curve (Θ_c):

$$\Delta\Theta = \Theta_{pn} - \Theta_c \qquad (4)$$

with a similar relation for the *radial* velocity difference ΔV. As shown by Maciel (1987), most type II PN have $|\Delta V| < 30$ km/s, deviating less than 20% from the rotation curve, which implies roughly that $200 < \Theta_{pn}$ (km/s) < 300. We consider the PN out of these limits to be subject of a probable error in d and/or V_{lsr}, amplificated by the factor sin l cos b in equation (2). In order to investigate possible kinematical differences among PN types, we use two different groups of objects as "control groups": (i) The 69 kinematically distinct CO-H II region complexes of Blitz et al. (1982) at the same distance range as our PN sample (d < 4 kpc), and (ii) the planetary nebulae of type III, which are clearly not associated with the disk both kinematically and spatially.

III. RESULTS AND DISCUSSION

Figure 1 shows the rotation velocity of planetary nebulae of different types and CO-H II complexes together with the reference curves. The curves labelled a, b, and c refer to PN of types I, IIa, and IIb, respectively. Figure 1a shows that the behaviour of type I nebulae is similar to that of CO-H II complexes, although the scatter is higher. It can be shown that plots of ΔV vs. R support such conclusion. Type IIa PN also define a reasonable rotation curve, although they seem to be located below the reference curves. This fact does not necessarily indicate a distinct behaviour, as this group of nebulae is distributed in a more limited range of R. The factor sin l cos b in equation (2) also accounts for the observed differences, as can be shown by plots of ΔV vs. R. In contrast, type IIb PN are more uniformly spread around the reference curves (Figure 1c), with a higher dispersion. Accordingly, the scale height Z also increases for PN of types I, IIa, and IIb (Figure 2). Type III PN (not shown in the figures) clearly deviate both from CO-H II complexes and the remaining PN types (except of course type IV PN, not included in this work). The histograms of Figure 2 also show the behaviour of CO-H II complexes and the different PN types. As can be seen from the figures, PN of types I and IIa display encouraging similarities with young, population I objects, so that they are good candidates to determine average rotation curves. Future steps in this investigation include increasing the available sample and considering in detail the influence of non-circular motions in the galactic disk.

Acknowledgements. This work was partially supported by CNPq and FAPESP.

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..21..264D

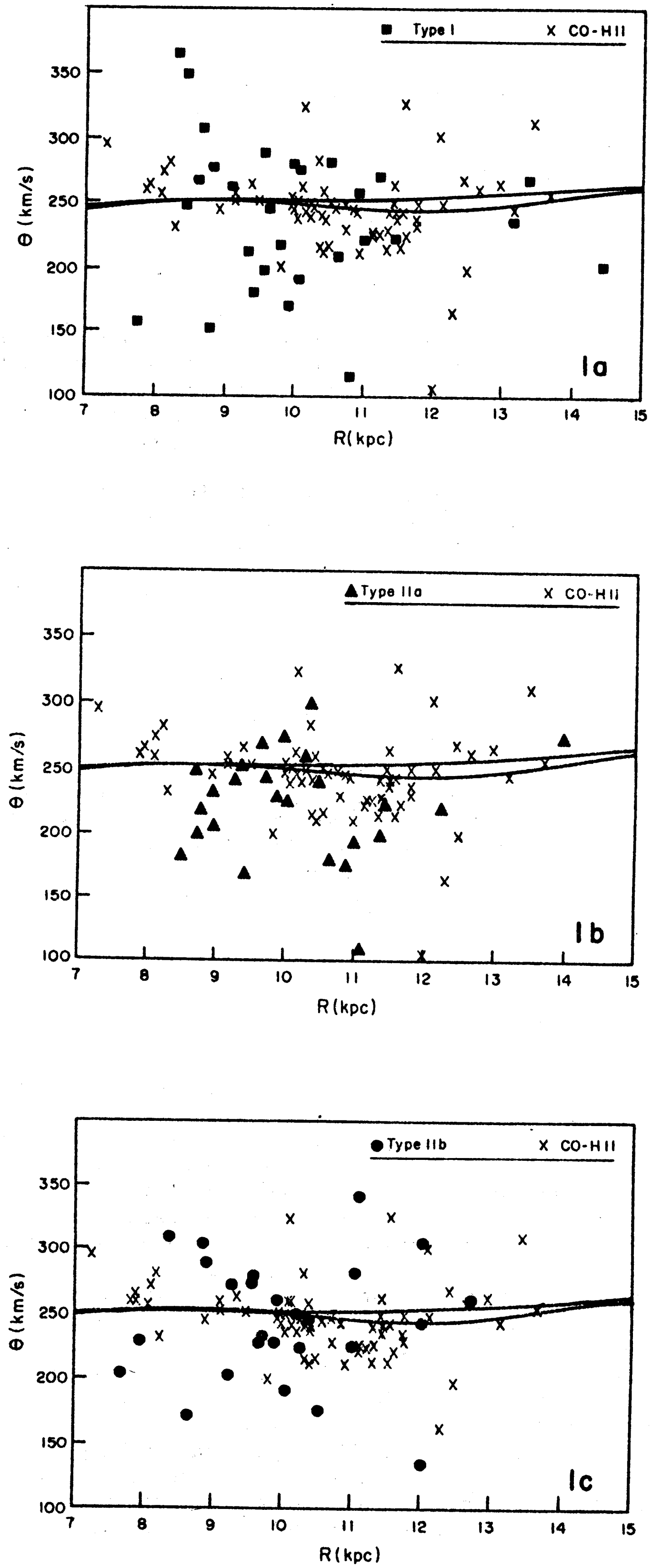

Figure 1 - Planetary nebulae and CO-Ḣ II complexes and the rotation curve

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..21..264D

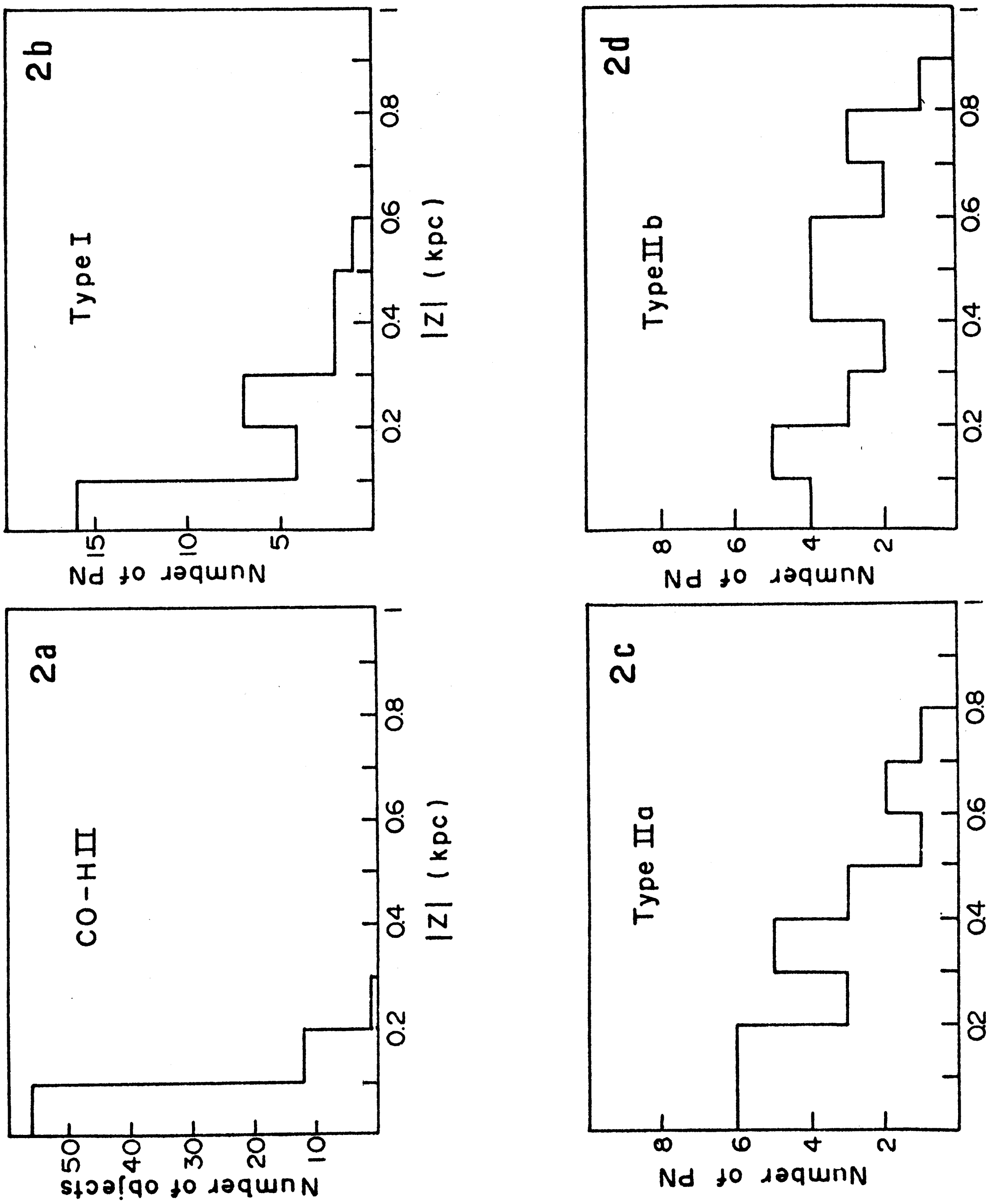

Figure 2 - Space distribution of planetary nebulae and CO-H II complexes

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System

1990RMxAA..21..264D

REFERENCES

Acker, A. 1978, Astr. Ap. Suppl. 33, 367
Blitz, L., Fich, M., Stark, A. A. 1982, Ap. J. Suppl. 49, 183
Clemens, D. P. 1985, Ap. J. 295, 422
Daub, C. T. 1982, Ap. J. 260, 612
Faúndez-Abans, M., Maciel, W. J. 1987, Astr. Ap. 183, 324
Maciel, W. J., Pottasch, S. R. 1980, Astr. Ap. 88, 1
Maciel, W. J. 1984, Astr. Ap. Suppl. 55, 253
Maciel, W. J. 1987, Late Stages of Stellar Evolution, ed. S. Kwok, S. R. Pottasch, Reidel
Maciel, W. J. 1989, IAU Symp. 131, ed. S. Torres-Peimbert, Kluwer, p. 73
Oliveira, S., Maciel, W. J. 1986, Ap. Sp. Sci. 128, 421
Peimbert, M. 1978, IAU Symp. 76, ed. Y. Terzian, Reidel, p. 215
Schneider, S. E., Terzian, Y. 1983, Ap. J. 274, L61
Schneider, S. E., Terzian, Y., Purgathofer, A., Perinotto, M. 1983, Ap. J. Suppl. 52, 399

Carlos M. Dutra and Walter J. Maciel: Departamento de Astronomia, Instituto Astronômico e Geofísico da USP, Caixa Postal 30.627, CEP 01051 São Paulo SP, Brazil.

© Universidad Nacional Autónoma de México • Provided by the NASA Astrophysics Data System