VELOCITY DISPERSION IN THE BULGE OF M 31 ; DYNAMICAL MODEL

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I - BASIC DATA

1) Photometry from de Vaucouleurs 1958 shows a bulge obeying the $r^{1/4}$ law up to less than 5 pc from the center with an effective radius r_e = 17'5. In the region from 0.01 to 0.2 r_e, equal luminosity curves are well approximated by similar ellipses of axial ratio 0.68. The reduced spatial density ν^* and the reduced gravitationnal potential ϕ^* (i.e. for a mass to luminosity ratio f equal to 1) can then be easily computed (Monnet and Simien 1977).

2) To compute the contribution of the nucleus to the overall gravitationnal potential we use the mass 4.5 10^7 $M_\odot$ found by Light et al. 1974.

3) Pellet 1976 has made spectrographic observations of stellar absorption lines in the range 4200 - 4400 Å at 1.3 Å resolution, and derived the mean rotation velocity integrated along the line of sight $< \Theta (x) >$ on the major axis. The tilt angle of M 31 is sufficiently small to permit the use of Bertola and Capaccioli 1975 formula for the computation of the mean rotationnal velocity of the stars Θ_m in the equatorial plane. It is quite linear from 0.01 to 0.2 r_e with a slope of 350 km s^{-1} in units of r_e.

4) The same observations, both on the major and the minor axis, are used to obtain the dispersion of radial velocities σ_v. A constant value of 140 (± 20) km s^{-1} is found in the interval 0.01 - 0.1 r_e, slightly higher than Morton et al. 1977 value (110 km s^{-1}) and using the same reduction process (fitting to an enlarged K_o III spectrum).

II - MODEL

We suppose that the galaxy is stationnary, axisymetric, and that there is no third integral. We also assume - as a working hypothesis - that the M/L ratio f (in the B band) is constant. The Jean's equations in the

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adimensionnal cylindrical coordinates r, θ, z can then be written :

$$(1)\quad \frac{\partial}{\partial z}(\nu^* \sigma_r^2) = f \nu^* \partial \phi^* / \partial z$$

$$(2)\quad \frac{\partial}{\partial r}(\nu^* \sigma_r^2) + \frac{\nu^*}{r}(\sigma_r^2 - \sigma_\theta^2) = \nu^* \frac{\Theta_m^2}{r} + f \nu^* \partial \phi^* / \partial r$$

where the σs' are the r.m.s. dispersions of the velocity components.

The gradients of the reduced potential ϕ^* are computed from ν^*(§ I, 1), using Schmidt 1956 formulae. We add the contribution of the nucleus (§ I, 2). The contribution of the disk is negligible. Equation (1) - with the limiting condition $\sigma_r(r, \infty) \equiv 0$ - gives then $\sigma_r(r, z)/f$ over all space (figure 1). The dispersion of the radial velocity integrated along the line of sight on the minor axis is :

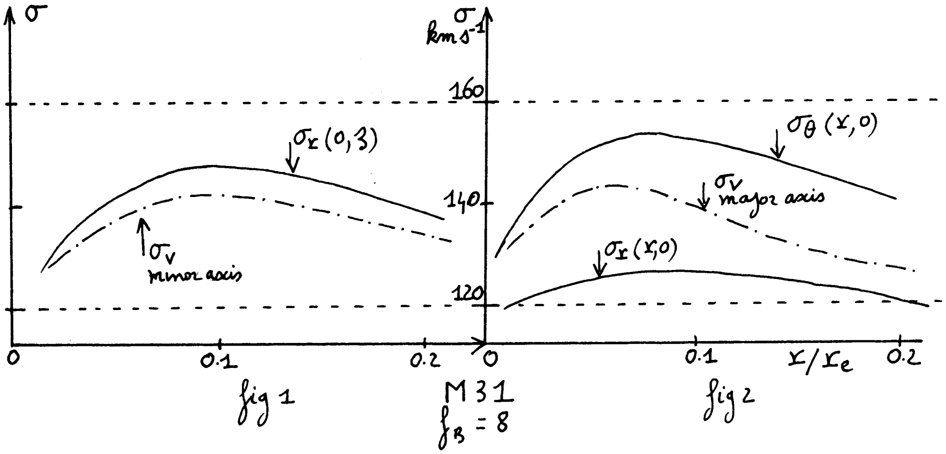
$$\sigma_v^2(0, z) = \int \sigma_r^2(u, z)\, \nu^*(u)\, du \Big/ \int \nu^*(u)\, du$$

Its computed values from 0.01 r_e to 0.2 r_e are shown in figure 1. The best fit to the experimental range (§ I, 4) occurs for f = 8 (± 2), which is compatible with the gas velocities on the North-East side.

Next we determine from equation (2) $\sigma_\theta(r, 0)$. Since, from 0.01 to 0.2 r_e log $\nu^* \simeq -7.32\,(r^{1/6} - 1)$ within 7 %, it can be written :

$$\sigma_\theta^2 = \sigma_r^2\,(1 - 2.81\, r^{1/6}) + r\, \partial \sigma_r^2 / \partial r - \Theta_m^2 - f\, \partial \phi^* / \partial r$$

$\sigma_\theta(r, 0)$ computed for f = 8 is shown in figure 2. $\sigma_\theta(r, 0)$ and $\sigma_r(r, 0)$ then give the dispersion of the radial velocity integrated along the line of sight on the major axis : $\sigma_v(r, 0)$. σ_v is given in figure 2.



Figures 1 and 2 :
σ_θ and the σ_r s' are given for a pure $r^{1/4}$ bulge law.
The σ_v s' include the nuclear contribution.

The good agreement with the experimental range confirms the M/L ratio adopted from the minor axis data. Correcting for a B Galactic absorption of 0.44 mag (Heidmann et al. 1961), the value is :

$$(M/L)_B = 5.3 \pm 1.3 \quad \text{for} \quad r < 0.2\, r_e \;.$$

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