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Fast bars in SB0 galaxies

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Abstract. We measured the bar pattern speed in a sample of 7 SB0 galaxies using the Tremaine-Weinberg method. This represents the largest sample of galaxies for which the bar pattern speed has been measured this way. All the observed bars are as rapidly rotating as they can be. We compared this result with recent high-resolution N-body simulations of bars in cosmologically-motivated dark matter halos, and conclude that these bars are not located inside centrally concentrated halos.

The pattern speed of a bar, Ω, is its main kinematic observable. When parameterised by the distance-independent ratio $\mathcal{R} \equiv D_L/a_B$ between the corotation radius, D_L, and the bar semi-major axis, a_B, it permits the classification of bars into fast ($1.0 \leq \mathcal{R} \leq 1.4$) and slow ($\mathcal{R} > 1.4$) ones. A model-independent method for measuring Ω directly was obtained by Tremaine & Weinberg (1984, hereafter TW). The TW method is given by the simple expression $\mathcal{X}\,\Omega\,\sin i = \mathcal{V}$, where $\mathcal{X}$ and $\mathcal{V}$ are luminosity-weighted mean position and velocity measured along slits parallel to the line-of-nodes. If a number of slits at different offsets from the major-axis are obtained for a galaxy, then plotting $\mathcal{V}$ versus $\mathcal{X}$ for the different slits produces a straight line with slope $\Omega \sin i$.

We defined a sample of 7 SB0 galaxies with intermediate inclination, a bar at intermediate position between the major and minor axes of the disk and no evidence of spirals and patchy dust (IC 874, ESO 139-G9, NGC 1308, NGC 1440, and NGC 3412: Aguerri et al. 2003; NGC 2950: Corsini et al. 2003; NGC 1023: Debattista et al. 2002). For each sample galaxy we obtained $I-$band imaging and long-slit spectra with slits parallel to the disk major axis. We measured Ω with the TW method. The corotation radius, $D_L \equiv V_c/\Omega$, was derived from the circular velocity, V_c, after applying the asymmetric drift correction to the stellar velocities and velocity dispersions. The length of the bar, a_B, was derived from the analysis of the surface brightness distribution. For all of the sample galaxies $\mathcal{R}$ is consistent with being in the range 1.0 to 1.4, within the errors, i.e. with each having a fast bar (Fig. 1). The unweighted average for the sample is $\overline{\mathcal{R}} = 1.1$. Some of the values of $\mathcal{R}$ are nominally less than unity; this suggests that the large range of $\mathcal{R}$ is a result of random errors and/or scatter.

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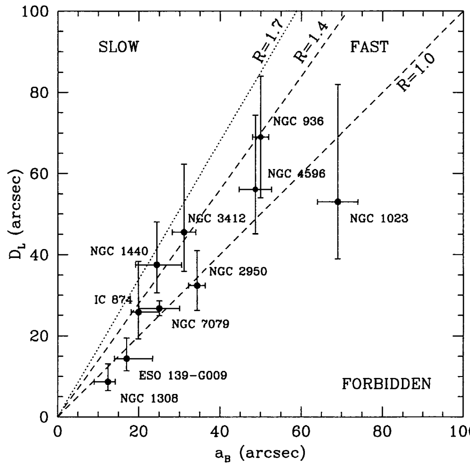

Figure 1. The corotation radius, D_L, and the bar semi-major axis, a_B, for our sample galaxies; NGC 936 (Merrifield & Kuijken 1995); NGC 4596 (Gerssen et al. 1997); and NGC 7079 (Debattista & Williams 2003). Dashed lines corresponding to $\mathcal{R} = 1.0$ and $\mathcal{R} = 1.4$ separate the fast-bar, slow-bar, and forbidden regimes.

Debattista & Sellwood (2000) argued that bars this fast can only survive if the disc in which they formed is maximal. Recent high resolution N-body simulations with cosmologically-motivated dark matter halos produce bars with $\mathcal{R}$ as large as 1.7 (Valenzuela & Klypin 2003). Even discounting our argument above in favour of a more restricted range of $\mathcal{R}$, Fig. 1 shows that $\mathcal{R} = 1.7$ is possible only for the bars of IC 874, NGC 1440, NGC 3412 and, marginally, NGC 936 (Merrifield & Kuijken 1995), while the bars of ESO 139-G009, NGC 1023, NGC 1308, NGC 2950, NGC 7079 (Debattista & Williams 2003), and NGC 4596 (Gerssen et al. 1997) never reach this value of $\mathcal{R}$. Therefore we conclude that the N-body models of Valenzuela & Klypin (2003) probably produce slower bars than those observed.

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