Disks of Galaxies : Kinematics, Dynamics and Perturbations
ASP Conference Series, Vol. 275, 2002
E. Athanassoula, A. Bosma & R. Mujica, eds.

The Gravitational Torque of Bars

I. Puerari

Instituto Nacional de Astrofísica, Optica y Electrónica, Calle Luis Enrique Erro 1, 72840, Tonantzintla, Puebla, Mexico

D.L. Block

Department of Computational and Applied Mathematics, University of the Witwatersrand, 1 Jan Smuts Avenue, Johannesburg 2001, South Africa

J.H. Knapen

Isaac Newton Group of Telescopes, Apartado 321, E-38700 Santa Cruz de La Palma, Spain and Dept of Physical Sciences, University of Hertfordshire, Hatfield, Herts AL109AB, UK

B.G. Elmegreen

IBM Research Division, TJ Watson Research Center, Box 218, Yorktown Heights NY 10598, USA

R. Buta

Dept of Physics and Astronomy, University of Alabama, Box 870324, Tuscaloosa, Alabama 35487, USA

S. Stedman

Dept of Physical Sciences, University of Hertfordshire, Hatfield, Herts AL109AB, UK

D.M. Elmegreen

Dept of Physics and Astronomy, Vassar College, Poughkeepsie, NY 12604-0278, USA

Abstract. We have determined the gravitational torque of a sample of 45 galaxies observed at K band with the 4.2m William Herschel Telescope. The results of this sample, combined with those for a sample of 30 galaxies previously analysed (Buta & Block 2001), show that the gravitational bar torque correlates only weakly with the optical bar type listed in the Revised Shapley-Ames and de Vaucouleurs systems. In fact, some classically unbarred galaxies have larger bar torques than classically barred galaxies. The Hubble classification scheme poorly recognizes the gravitational influences of the bar perturbation in the force field.

1. Introduction

Even that bar structures have been recognized in galaxies at earlier times (Curtis 1918; Hubble 1926), only recently methods have been developed to quantify the importance of these structures on galaxy structure. The quantification of the bar structures in galaxies is very important because a number of galactic phenomena may be linked to these bisymmetrical perturbations (for example, angular momentum transfer, non circular motions, gas inflow, nuclear activity, starburts, lack of abundance gradients, as well as the shapes and morphologies of rings and spirals).

In the past, bar classification was performed "visually" from galaxy images on blue sensitivity photographic plates. Hubble (1926) and de Vaucouleurs (1959) developed qualitative bar classification schemes. However, these schemes can not be expected to be accurate measurements of bar strenght because they depend on the observer interpretations. Furthermore, blueish wave–bands are not suitable for the determination of galatic structures, because they are strongly affected by dust. Studies as those from Block & Wainscoat (1991), Block & Puerari (1999), Knapen, Shlosman, & Peletier (2000) and Eskridge et al. (2000), among others, have clearly shown that near–infrared is the best wavelength regime for judging galactic structures such as spiral arms and bar strengths.

In view of this, in this contribution we used a quantitative method introduced by Combes & Sanders (1981) and recently improved by Buta & Block (2001) to analyse the bar strength of galaxies observed at the near–infrared. The data and analysis are presented in the next section, followed by a discussion and conclusions.

2. Data and analysis

The galaxies were observed at the K band with the 4.2m William Herschel Telescope using the Isaac Newton Group Red Imaging Device INGRID. Detailed information can be found in Block et al. (2001). The galaxies were selected to cover a wide range of Hubble types, de Vaucouleurs class as well as form family. Our sample also covers the full range of Elmegreen arm class (Elmegreen & Elmegreen 1987), from flocculent classes 1–3 to grand–design 9–12 classes. More details of this sample can be found in Stedman & Knapen (2001). This former sample was combined with that one already discussed in Buta & Block (2001). Using these two samples, we have a total of 75 galaxies observed at the near–infrared (mainly at K and K′ bands).

For the calculation of bar strenghts, we follow the procedure already fully explained with details in Buta & Block (2001). The reader can refer to that article to get more information about the determination of bar strength. In short, the procedure can be resumed in the calculation of the ratio between the maximum of the tangential force and the mean radial force (see also Combes & Sanders 1981). Forces are calculated by transforming the deprojected near–infrared light distribution into potential.

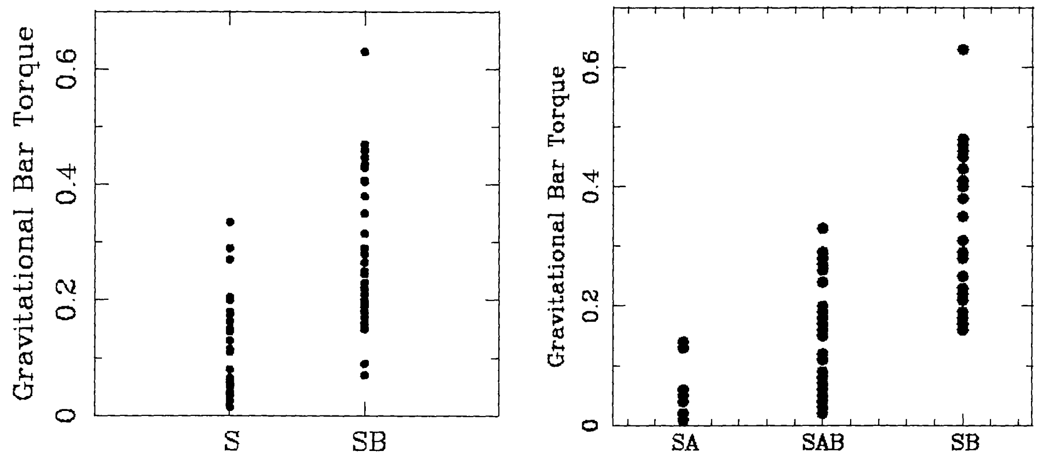

Figure 1. Left: Gravitational bar torque versus Hubble classification as prescribed in the RSA Catalog (Sandage & Tammann 1981). Right: Gravitational bar torque versus the de Vaucouleurs (1963) form family.

3. Discussion

In Figure 1 we plot our values of bar strength versus Hubble type (letf panel) and versus the de Vaucouleurs form family (right panel). We can see that there is a general trend indicating that the "visual, qualitative" classification and the bar strength are in agreement. But we have to note that the dispersion in these plots is quite large. Classical unbarred S galaxies can have bar strengths as high as classical barred SB galaxies.

We have also compared our bar strength determination with a quantity generally used as a measure of the bar strength, although it is a morphological characteristic: the axis ratio (circular structures have axis ratio equal to 1 and strongly elongated structures have axis ratio near to zero). In Figure 2 we plot our values of bar strength versus the deprojected axis ratio determined by Martin (1995). As in Figure 1, we can see a general trend between these two quantities, but once more, the dispersion is quite large, and highly elongated "strong" bars in the definition of Martin (1995) may have weak gravitational bar torques.

4. Conclusions

We have analysed the gravitational bar torque of a sample of 75 galaxies, which optically cover a wide range of morphological characteristics. We have show that, even that there is a general trend between qualitatively classified bar families and bar torques, there is a wide dispersion and classical unbarred galaxies can have bar torques as high as classical barred galaxies. It was also shown that the axis ratio correlates also weakly with the bar strength. Elongated bar structures may have weak bar strength. The visual appearence of the bar structure does not determine the influence of it in the force field.

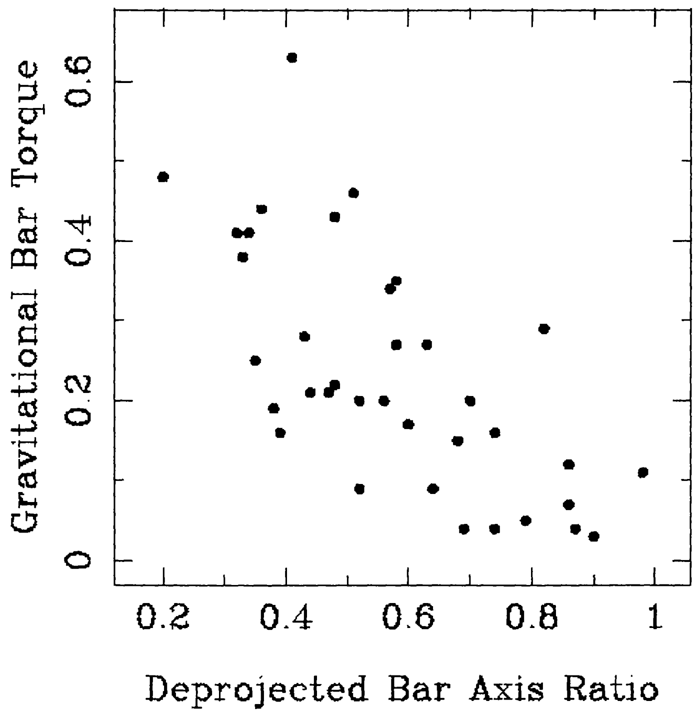

Figure 2. Gravitational bar torque plotted versus deprojected bar axis ratio determined by Martin (1995). Note the high dispersion, indicating that even highly elongated "strong" bars in the definition of Martin (1995) may have weak gravitational bar torques.

References

Block, D.L., & Puerari, I. 1999, A&A, 342, 627

Block, D.L., Puerari, I., Knapen, J.H., Elmegreen, B.G., Buta, R., Stedman, S., & Elmegreen, D.M. 2001, A&A, 375, 761

Block, D.L., & Wainscoat, R.J. 1991, Nature, 353, 48

Buta, R., & Block, D.L. 2001, ApJ, 550, 243

Combes, F., & Sanders, R.H. 1981, A&A, 96, 164

Curtis, H.D. 1918, Pub. Lick Obs. XIII, Part I, 11

de Vaucouleurs, G. 1959, Handbuch der Physik 53, 275

de Vaucouleurs, G. 1963, ApJS, 8, 31

Elmegreen, D.M., & Elmegreen, B.G. 1987, ApJ, 314, 3

Eskridge, P. et al. 2000, AJ, 119, 536

Hubble, E. 1926, ApJ, 64, 321

Knapen, J.H., Shlosman, I., & Peletier, R.F. 2000, ApJ, 529, 93

Martin, P. 1995, AJ, 109, 2428

Sandage, A., & Tammann, G. 1981, "A Revised Shapley–Ames Catalog of Bright Galaxies" (Carnegie Institute, Washington, DC)

Stedman, S., & Knapen, J.H. 2001, Ap&SS, in press