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BAR PARAMETERS OF SEYFERT AND INACTIVE GALAXIES

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Abstract. We present a comparative analysis of the distribution and correlations of the bar parameters ellipticity, length, and relative length for a sample of Seyfert galaxies and a control sample of inactive galaxies. We extend the relation between the bar length, corresponding to the ellipticity maximum and to a 15 % decrease in ellipticity maximum, with seven more galaxies. There is no significant difference in the distribution of both absolute and relative bar length for the two samples; the bar ellipticity appears lower for the Seyfert galaxies. We found no strong correlation for the (relative) bar length vs. bar ellipticity and for the bar length vs. galaxy radius with similar behaviour for the two samples.

1. INTRODUCTION

Galaxy total energy would be minimal in the presence of outflowing angular momentum (Lynden-Bell & Kalnajs 1972). Angular momentum exchange is the motor of secular evolution of galaxies. The main internal angular momentum transfer mechanism is due to the torques exerted by the bar on the gas. Depending on the relative angular frequency of the bar and disk, resonances can occur. The torques change sign at each resonance and drive the accumulation of gas in the form of rings (Combes 2001).

The basic bar parameters are length and strength. Bar length is proportional to the part of the host galaxy that can be affected dynamically by the bar (Erwin 2005). There are various bar length estimation methods: visual inspection, analysis of the surface brightness profile over the bar major axis, ellipse fitting, Fourier analysis (Erwin 2005; Michel-Dansac and Wozniak 2006). The semi-major axis corresponding to the ellipticity maximum is considered the most objective and reproducible bar length estimate. However, it is not related to any of the bar dynamical characteristics (Michel-Dansac and Wozniak 2006). Bar strength is the maximal tangential force in terms of the mean radial force (Combes and Sanders 1981). It was shown that deprojected bar ellipticity is a first order approximation of bar strength (Athanassoula 1992; Block et al. 2004).

2. DATA ANALYSIS AND RESULTS

We use a sample of 35 Seyfert galaxies and a control sample of inactive galaxies. The sample selection and data reduction are described in Slavcheva-Mihova and Mihov (2011a). In Slavcheva-Mihova and Mihov (2011b) we estimated the bar length, ℓ, and ellipticity, ϵ. Inspired by the finding of Martinez-Valpuesta et al. (2006) that the bar length corresponding to 15 % decrease of ellipticity from its maximal value is related to the size of the maximal stable x_1 orbit, as bar length we adopted the minimum of the semi-major axes corresponding to 15 % ellipticity decrease at both sides of the profile. The so estimated bar length was found to correlate tightly with the bar semi-major axis corresponding to the ellipticity maximum, ℓ_{max}, with a median ratio of 1.216 $\pm$ 0.019 based on 14 Seyfert galaxies (Slavcheva-Mihova and Mihov 2011b). Now we extend this ratio with seven inactive galaxies. The median value of ℓ/ℓ_{max} is 1.218 $\pm$ 0.023 based on the inactive galaxies and 1.218 $\pm$ 0.014 for the combined set of 21 Seyfert and inactive galaxies.

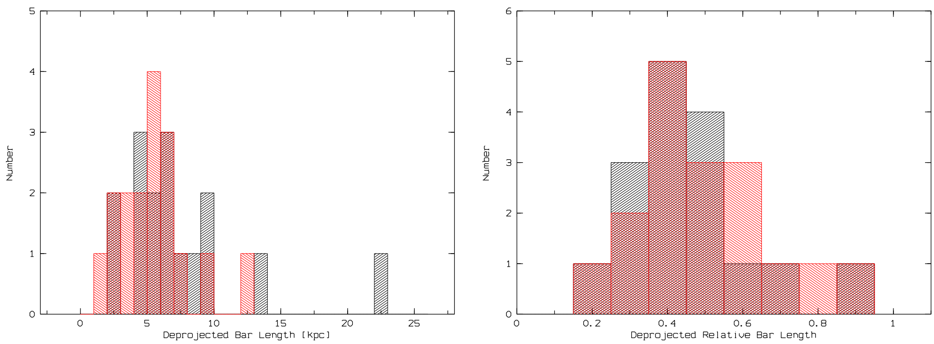

Figure 1: Distribution of the deprojected bar length (left panel) and deprojected relative bar length (right panel) for the Seyfert (left hashed, red) and inactive (right hashed, black) galaxies (see electronic version).

Both bar length and ellipticity were deprojected. The relative bar length is in terms of the galaxy radius corresponding to the 25 B mag arcsec^{-2} isophote, corrected for Galactic extinction as reported in HyperLeda[1] (Paturel et al. 2003). We further applied K- and E- corrections, as well as a correction for cosmological dimming. The deprojection and corrections are described in Slavcheva-Mihova and Mihov (2011b).

We compared the distribution of bar parameters for the two samples (Figs. 1 - 2). The median value of the bar length, relative bar length, and bar ellipticity is 5.44 $\pm$ 0.63/6.12 $\pm$ 1.27, 0.45 $\pm$ 0.05/0.43 $\pm$ 0.04, and 0.39 $\pm$ 0.04/0.49 $\pm$ 0.04 for the Seyfert/inactive galaxies. The difference in the distribution of both bar length and relative bar length is insignificant for the two samples at the 95 % confidence level. At this confidence level the Seyfert bars have lower bar ellipticity than the inactive ones, i.e. the Seyfert bars appear weaker as discussed in Slavcheva-Mihova and Mihov (2011a).

[1] http://leda.univ-lyon1.fr

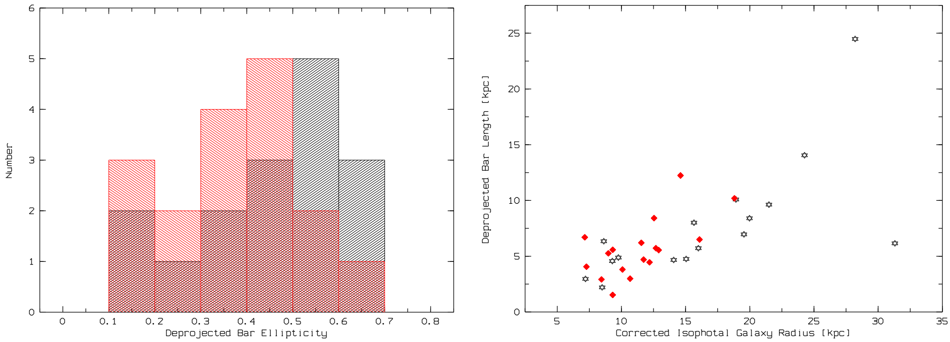

Figure 2: The same as in Fig. 1 but for the deprojected bar ellipticity (left panel) and deprojected bar length vs. corrected isophotal galaxy radius for the Seyfert (red diamonds) and inactive (black stars) galaxies (right panel) (see electronic version).

Furthermore, we studied the correlations among the bar parameters and between them and the galaxy parameters. We found a weak correlation between the deprojected bar length and corrected isophotal galaxy radius with a Pearson correlation coefficient $r = 0.63$ for the Seyfert and $r = 0.65$ for the inactive galaxies (Fig. 2). The deprojected bar length/relative bar length shows no clear correlation with the deprojected bar ellipticity (with $r = 0.44/r = 0.51$ for the Seyfert and $r = 0.36/r = 0.30$ for the inactive galaxies; Fig. 3).

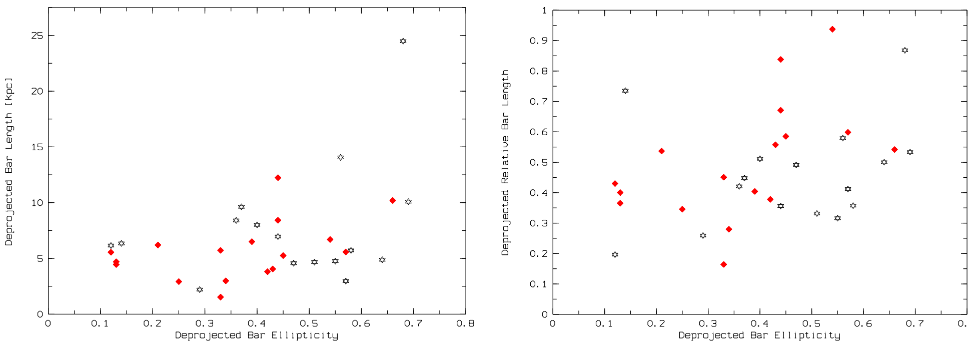

Figure 3: Deprojected bar length vs. deprojected bar ellipticity (left panel) and deprojected relative bar length vs. deprojected bar ellipticity (right panel); the symbols are as in Fig. 2.

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