Formation and evolution of Galaxy Bulges
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Bar strengths in early-type disk galaxies

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Abstract. Using the gravitational torque indicator Q_b, we derive the distribution of bar strengths for a sample of early-type disk galaxies. The sample is part of the Near-Infrared S0 Survey (NIRS0S), designed to examine the properties of bars, bulges, and disks in galaxies classified as types S0$^-$ to Sa. Although the survey is only partly finished, we find that the distribution of bar strengths in S0 galaxies differs from that in spirals by lacking an extended tail to high values of Q_b. No S0 in our current sample has $Q_b > 0.25$, while spirals extend to $Q_b \approx 0.7$. Bars having $Q_b > 0.25$ first appear among S0/a to Sa galaxies.

Keywords. galaxies: structure; galaxies: spiral; galaxies: bulges

1. Introduction

The gravitational torque method (GTM, Laurikainen *et al.* 2004 and references therein) provides a reasonable way of quantifying the strengths of bars in disk galaxies. The method uses near-infrared images to infer gravitational potentials and estimate maximum relative torques due to bars and spirals. Near-infrared images are best for this purpose because these are less affected by extinction and stellar mass-to-light ratio variations than optical images.

The Near-Infrared S0 Survey (NIRS0S) is a comprehensive examination of the properties of bars, bulges, and disks in early-type galaxies (Laurikainen *et al.* 2006, Buta *et al.* 2006). The survey includes 193 galaxies having RC3 types S0$^-$ to Sa, total magnitude $B_T \leqslant 12.5$, isophotal axis ratio $\log R_{25} \leqslant 0.35$, and allows for some of the uncertainty in classifying E and S0 galaxies by also utilizing other sources of classifications. Early-type spirals are included to bridge the "spiral/S0 divide." The survey is being based mainly on 2.15 μm K-short (K_s) images, supplemented in some cases by 1.25 μm J-band images and optical B- and V-band images.

In addition, we have tested the use of Sloan Digital Sky Survey (SDSS) 0.8 μm i-band images for the survey, since the SDSS area includes 1/3 of our sample galaxies. Although more seriously affected by extinction than K_s-band images, SDSS i-band images still contain useful information owing to the generally low dust content of S0s. The principal goal of the NIRS0S is to derive the distribution of bar strengths in S0 galaxies and to compare this distribution with those for early and later type spirals. We present the first detailed comparisons here.

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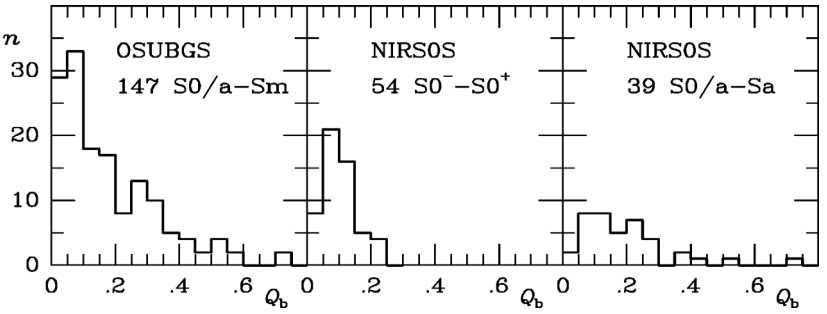

Figure 1. Distribution of bar strengths in early-type galaxies.

2. Results

SDSS i-band images were used for 57 NIRS0S galaxies. These images were analyzed in a similar manner to our J and K_s-band images. Images were cleaned of foreground stars and sky-subtracted, and a 2D multi-component decomposition code was used to derive bulge and disk properties. For 53 of these galaxies, the mean Sersic index and bulge-to-total luminosity ratio were derived to be $< n >$=1.9±0.6 and $< B/T >$=0.30±0.18, respectively. These values are consistent with our previous K_s-band studies (see Laurikainen *et al.*, these proceedings), and indicate a preponderance of "pseudobulges." Bar strengths were derived from deprojected images assuming the bulges to be spherical. From 15 galaxies in common to our K_s-band sample we find $< Q_b(SDSS\ i) - Q_b(K_s) > = -0.003 \pm 0.045$, indicating no systematic offset. Thus, we have combined our SDSS i-band bar strengths with our K_s-band bar strengths, giving us 54 S0 galaxies and 39 S0/a and Sa galaxies. This is only about half the final sample intended for the NIRS0S.

Figure 1 shows the distribution of bar strengths for the NIRS0S as compared to the distribution obtained for 147 Ohio State University Bright Galaxy Survey (OSUBGS) galaxies by Buta *et al.* (2005). The most noteworthy feature of these histograms is the complete absence of an extended "tail" of high Q_b galaxies among S0s. The OSUBGS sample and the NIRS0S S0/a and Sa sample both show galaxies to $Q_b \approx 0.7$, while no S0 we have so far observed has $Q_b > 0.25$. In the external gas accretion models of Block *et al.* (2002), the extended tail seen for spirals is due mainly to bar renewal. The lack of an extended tail in the S0 distribution could simply mean that these galaxies are not accreting any external gas, or that they generally have significant bulges that dilute the torques enough to eliminate a tail.

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