The Fundamental Plane of Bulges

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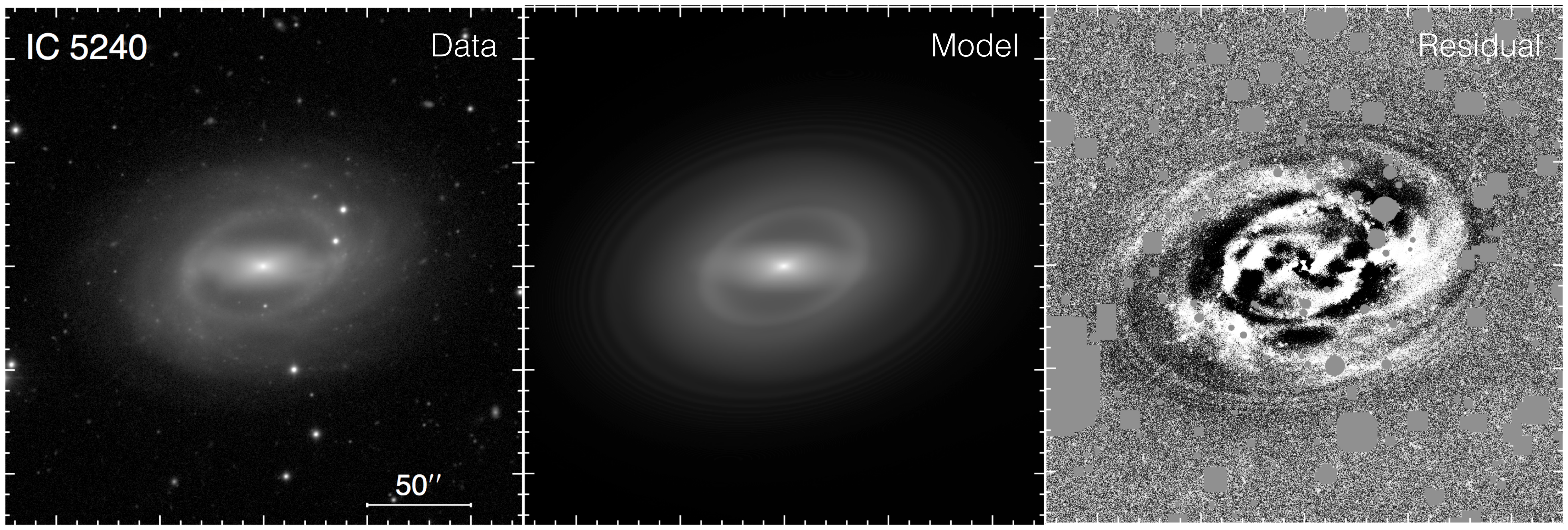
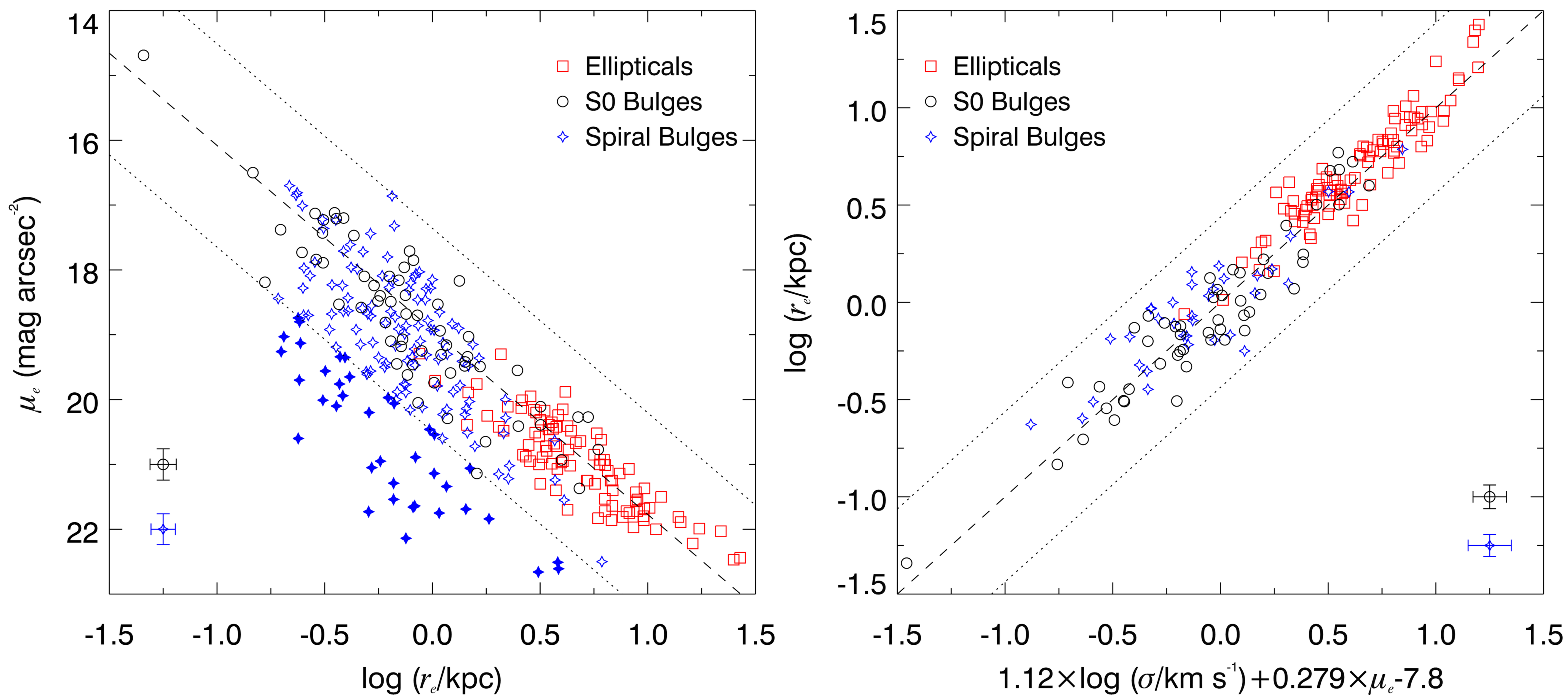


Figure 1. Example fit to IC 5240. The panels display, from left to right, the grayscale *R*-band data image, the best-fit model image, and the residual image.

We present detailed multi-component decompositions of high-quality *R*-band images of nearby disk galaxies selected from the Carnegie-Irvine Galaxy Survey (Ho et al. 2011; Gao & Ho 2017; see Fig. 1 for an example). Using structural parameters of their bulges, we measure the Kormendy relation and the fundamental plane (Fig. 2). We find that bulges of S0s, as low-luminosity extensions to ellipticals, form a surprisingly uniform population in both scaling relations, despite their wide range of prominence (Fig. 3a; Gao et al. 2018). On the other hand, some bulges of spirals appear as 3-sigma outliers in the Kormendy relation. The outliers have small bulge-to-total ratios ($B/T \lesssim 0.1$), faint surface brightness ($\mu_e \gtrsim 18$ mag arcsec^{-2}), and small sizes ($r_e \lesssim 1$ kpc), generally in agreement with previous perception of pseudobulges (Kormendy & Kennicutt 2004). However, it is worthy of notice that these pseudobulge candidates do not always have low Sérsic indices ($n \lesssim 2$; Fig. 3b; but see Fisher & Drory 2008). They have a distinct apparent ellipticity distribution from the rest of the bulges, which is reminiscent of the difference between apparent ellipticities of disks and spheroids (Sandage et al. 1970). We quantitatively study the intrinsic flattening of the pseudobulge candidates by comparing their apparent ellipticities to those of spirals and ellipticals (Fig. 4). Through K-S tests, we find that they have compatible intrinsic shapes with spiral disks but differ from ellipticals, which is consistent with their presumed disky nature. The rest of the bulges (classical bulges) show an opposite behaviour. This reinforces our belief in the application of the Kormendy relation to distinguish bulges of different nature (Gadotti 2009). As S0s host exclusively classical bulges and late-type spirals host most of the pseudobulges, and environmental effects that may account for such evolution appear to be minimal, we suggest that late-type spirals are not plausible progenitors of S0s.

Figure 2. The Kormendy relation (left) and the edge-on view of the fundamental plane (right) of galaxy spheroids. Filled stars are outliers.



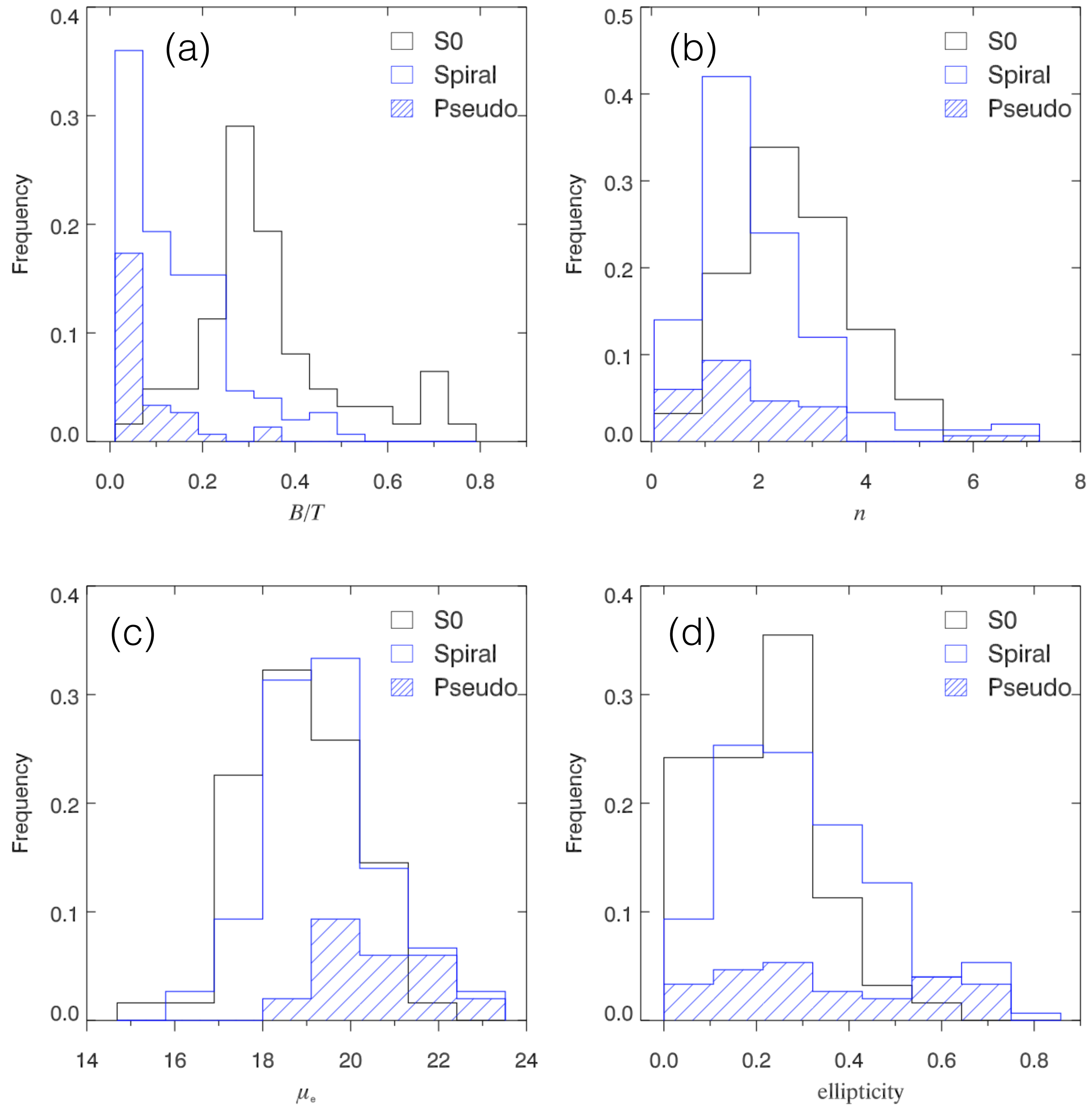


Figure 3. Distributions of (a) *B/T*, (b) *n*, (c) μ_e, and (d) apparent ellipticity of S0 bulges (black), spiral bulges (blue), and pseudobulges (blue filled).

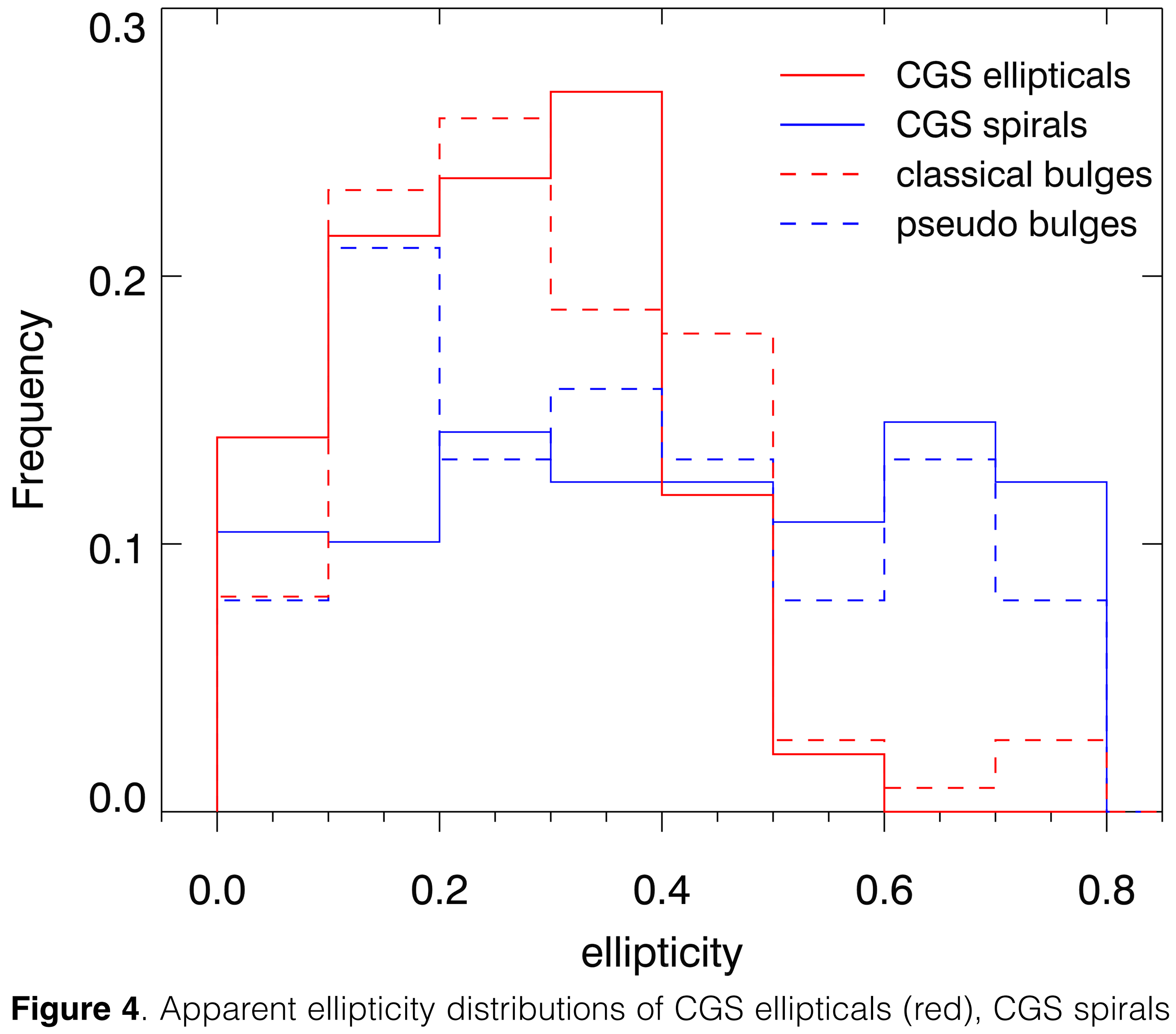


Figure 4. Apparent ellipticity distributions of CGS ellipticals (red), CGS spirals (blue), classical bulges (red dashed), and pseudo bulges (blue dashed).

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