THE EFFECTS OF THE DISK FIELD ON THE BULGE SURFACE BRIGHTNESS

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1. Introduction, N-body method and results

After the classical description of bulges by a de Vaucouleurs profile was found to be inadequate, a generalized profile, Sersic's law, was used successfully to describe the surface brightness:

$$\Sigma_n(r) \propto \exp(-r/r_0)^{1/n}$$

(Andredakis et al. 1994 (APB95)). The exponent n was found to vary systematically with the morphological type of the galaxy, from $n = 4$ for the bulges of S0s to $n = 2$ for intermediate type spirals and $n = 1$ (pure exponential) for the late types. (APB95, de Jong 1996). This has been confirmed also by the kinematics (Heraudeau et al 1996). This variation of n has been interpreted in two ways: **(i)** As the effect of the disk forming around an already developed bulge (APB95) and **(ii)** as evidence that the bulge originated from secular processes in the galaxy, *after* the disk was formed (Courteau et al. 1996). This needs to be resolved.

We use N-body simulations to study the effects of disk formation on the bulge. The initial bulge is a spherical, isotropic $R^{1/4}$ law system, consisting of 32,000 particles. After extensive tests to ensure the stability of the system, the potential of an exponential disk is slowly grown inside and around the bulge. A range of values is used for the disk mass and scalelength: The B/D ratio ranges from 0.05 to 2, and $(h_d/R_{\rm eff})$ from 1.5 to 10. After the disk growth is complete, Sersic's law is fitted to the profile.

The n of the bulge profile does indeed decrease from 4, initially, to smaller values; More massive and more compact disks produce a smaller n. But the final n of the bulge never neaches 1–the surface brightness profile never becomes exponentially steep. This is shown in Fig. 1a. For the bulges

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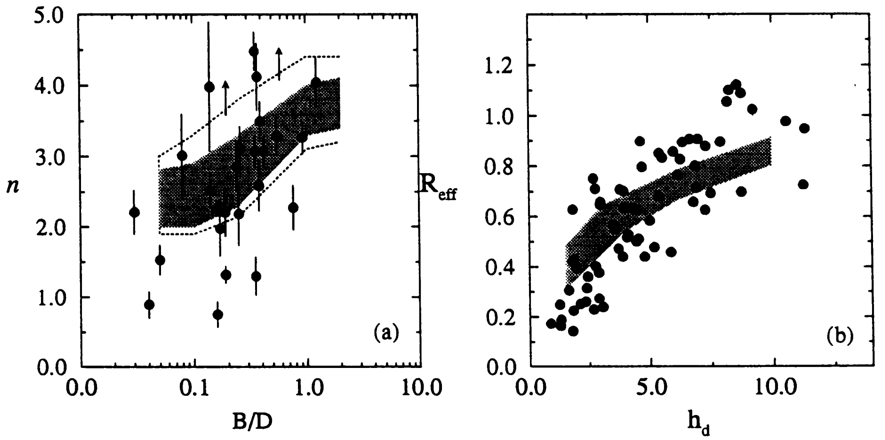

Figure 1. The observed correlations (data points) and the ones resulting from the simulations (shaded areas).

with $n > 2$ the two correlations, observed and predicted, generally agree. The predicted $n - B/D$ relation levels off at $n = 2$, however; bulge profiles become more resistant to change, as they become steeper!

Another aspect of these simulations is the predicted change the effective radius of the bulge. This creates a correlation between disk scalelength and bulge $R_{\rm eff}$. This kind of correlation has been observed in galaxies, (Courteau et al 1996) and has been interpreted as evidence for secular evolution origin of bulges. Very roughly, big disk **creates** big bulge, small disk **creates** small bulge. Here it is shown that what happens is that an already existing bulge is *cut short* by a compact disk. This result is shown in Fig. 1b.

2. Conclusions

The growth of the disk changes the shape of the surface brightness profile of a pre-existing bulge. The index n of the best-fit Sersic law decreases from the initial value of 4 down to a limit of 2. A large part of the relevant observed correlation is explained. Exponential bulges, however, remain unexplained by this mechanism, leaving open the bar-origin.

The correlation of bulge R_{eff} with disk scalelength can be almost entirely explained by the disk growth around an already existing bulge. No secular-evolution formation scenarios need be invoked, except perhaps for the smallest bulges.

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