OPTICAL ROTATION CURVES OF DISTANT GALAXIES : KINEMATICS AND EVOLUTION OUT TO $z \sim 1$

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Spatially resolved velocity profiles are presented for 12 faint field galaxies in the redshift range $0.1 \lesssim z \lesssim 1$ based on moderate–resolution spectroscopy obtained with the Keck 10m telescope. These data were augmented with high–resolution *Hubble Space Telescope* images from *WFPC2*, which provided V and I photometry, galaxy type, orientation, and inclination. The effects of seeing, slit width, and slit misalignment with respect to galaxy major axis were modeled along with inclination for each source, in order to derive a maximum circular velocity from the observed rotation curve. The rotation curves appear similar to those of local galaxies in both form and amplitude, implying that some massive disks were in place at $z \sim 1$. The key result is that the kinematics of these distant galaxies show evidence for only a modest increase in luminosity ($\Delta M_B \lesssim 0.6$) compared to velocity–luminosity (Tully–Fisher) relations for local galaxies.

The correlation between rotational velocity and luminosity of disk galaxies provides a powerful tool with which to study distant galaxies and to investigate galaxy evolution. Galaxy evolution models range from those with mild amounts of luminosity brightening in the past (Gronwall & Koo 1995) to those requiring more dramatic changes (Glazebrook *et al.* 1995). By comparing a distant sample of rotation curves to local TF relations, we can directly constrain the global brightening of disk galaxies in the past.

Twelve inclined disk galaxies with *WFPC2* images have been observed on the Keck telescope; spatially resolved major axis velocity profiles have been acquired using a 600 line mm^{-1} grating (1.26 Å and (0.″215 per pixel) for emission lines ranging from Hα through [O II] λ3727. Gaussian profiles were fit to these rotation curves, and an exponential disk model with flat terminal velocity was used to deconvolve the effects of slit width and position angle, inclination, and seeing to derive a maximum circular velocity for each galaxy.

The shapes of the rotation curves of these high redshift galaxies are similar to those of local galaxies. The high–redshift rotation curves are relatively symmetric, show a "solid–body" rise in the inner regions, and turn over to a relatively constant circular velocity in the outer parts. The maximum velocities are comparable to those of local spirals. Rough calculations yield masses between 1 and $5 \times 10^{11}\ M_{\odot}$, well within the range of masses found for nearby spiral galaxies. Notably, the kinematics of these distant galaxies show evidence for only a modest increase in luminosity of $\Delta M_B \lesssim 0.6$ compared to

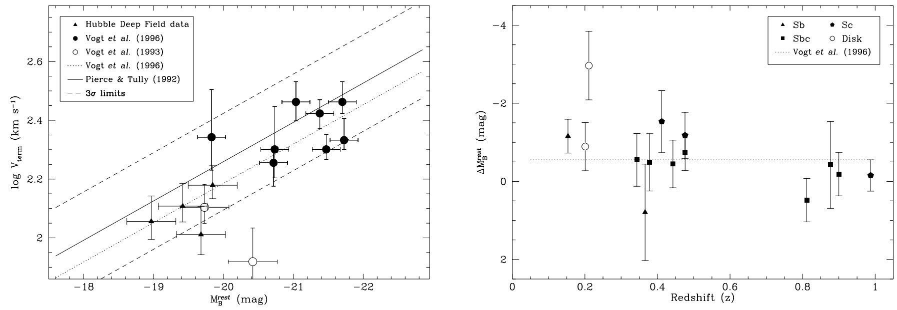

Figure 1: (A) Four recently observed galaxies from the *Hubble Deep Field* area and ten galaxies from Vogt *et al.* (1996,1993) are compared to the Pierce & Tully (1992) relationship based on HI velocity width measurements for a set of cluster spirals, shown by the best–fit B–band relation (solid line) and 3σ limits (dashed lines). The weighted fit to the eight galaxies from Vogt *et al.* (1996) (dotted line; assuming the same slope) produces an offset of 0.55 ± 0.16 mag, and the *Hubble Deep Field* area data confirms this trend, and extends it towards intrinsically lower luminosity galaxies (L^* corresponds to $M_B \sim$ -20.4). Data have been corrected for internal extinction, and we assume $H_0 = 75$ km s^{-1} Mpc^{-1} and $q_0 = 0$. (B) Brightening relative to the Pierce and Tully relationship is shown, and the weighted fit to the eight galaxies from Vogt *et al.* (1996) (dotted line). There is no notable increase in brightening as a function of redshift, nor is there a clear trend with type.

Tully-Fisher relations for local galaxies.

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