

## The Tully-Fisher Relation in Cl0024+1654 at $z=0.4$

Anne J. Metevier and David C. Koo

*Department of Astronomy & Astrophysics, University of California,  
Santa Cruz, CA 95064, USA*

**Abstract.** We present the Tully-Fisher relation in cluster Cl0024+1654 at  $z=0.4$ . We find that our sample of 15 distant cluster members are  $\sim 0.5$  mag overluminous as compared to local galaxies, and they exhibit slightly more Tully-Fisher scatter. This scatter is correlated with galaxy colours and sizes such that the smallest and bluest Cl0024 members in our sample are most overluminous.

### 1. Background and Analysis

The Tully-Fisher relation (TFR), a tool for studying galaxy mass-to-light ratios, is a powerful diagnostic of evolutionary processes. This is particularly the case in galaxy clusters, where processes such as ram-pressure stripping and galaxy harassment are likely to affect galaxy M/L. Here we present the TFR in a  $z=0.4$  cluster Cl0024+1654. Cl0024 is an excellent cluster for this study as it is known to have a high fraction of blue members (Butcher & Oemler 1978) and may have undergone a recent interaction with a nearby subcluster (Czoske et al. 2002).

We have derived rotation velocity measurements for 15 cluster members from Keck (LRIS) spectra. Our analysis fully accounts for the effects of seeing, slit effects, and instrumental resolution. Relevant structural parameters such as inclination, size, and orientation were made from HST (WFPC2) images and incorporated into the analysis. See Figure 1 for an example rotation curve.

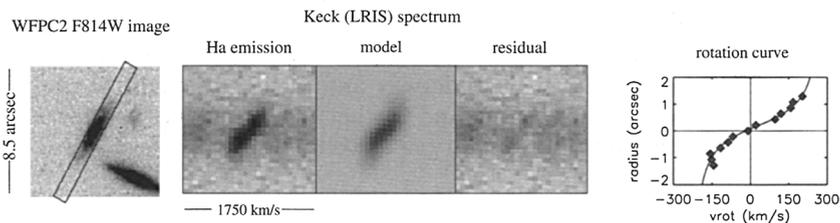


Figure 1. (Left): HST image of a Cl0024 member with slit overlaid. (Middle):  $H\alpha$  emission from the object spectrum, a best-fit model emission line, and the residual spectrum. (Right): Extracted velocity curve.

## 2. Cl0024 Tully-Fisher Relation

In Figure 2, we present the Cl0024 Tully-Fisher relation. We find that four of the 15 distant cluster members in our sample exhibit anomalous kinematics such as distorted rotation curves (in two cases), a ring of emission (in one case) and AGN signatures (in one case). Comparing the “normal” galaxies in our sample to the local TFR derived by Tully & Pierce (2000), we find that the Cl0024 members are  $\sim 0.5$  mag overluminous.

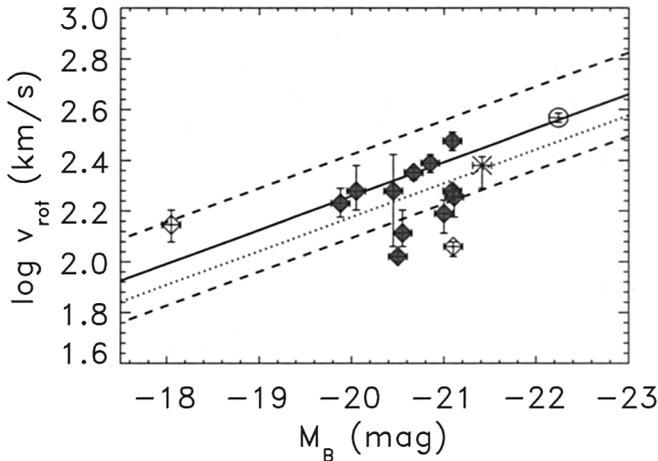


Figure 2. Cl0024 Tully-Fisher relation. Open symbols represent objects which exhibit anomalous kinematics. Solid and dashed lines are the local TFR and  $3\sigma$  errors derived by Tully & Pierce 2000. Dotted line is best-fit to “normal” Cl0024 sample (solid symbols).

From Figure 2, it is also clear that our Cl0024 sample exhibits slightly more Tully-Fisher scatter than is seen in the local relation. This is the case even when accounting for our larger measurement errors. We find that the scatter in the Cl0024 TFR is correlated with galaxy colours and sizes, indicating that the smallest and bluest cluster members are most overluminous and likely the most rapidly evolving (see Metevier et al. 2003 for more details). Further analysis of Cl0024 disk galaxies is underway and includes structural analysis of Cl0024 members from HST imaging and further measurements of emission line diagnostics (e.g., star formation rates, gas metallicities) from Keck spectra.

## References

- Butcher, H., & Oemler, A. 1978, *ApJ*, 219, 18  
 Czoske, O., Moore, B., Kneib, J.-P., & Soucail, G. 2002, *A&A*, 285, 426  
 Metevier, A. J., Koo, D. C., Simard, L., & Phillips, A. C. 2003, *ApJ*, submitted  
 Tully, R. B., & Pierce, M. J. 2000, *ApJ*, 533, 744