NOAO Observing Proposal | **Panel:** *For office use.*
Date: September 19, 2007 | **Category:** Galactic - Other

Observing high red shift galaxies for Tully Fisher relationship

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Abstract of Scientific Justification *(will be made publicly available for accepted proposals)*:

We propose to study the Tully-Fisher (TF) relationship over a range of redshifts to better calibrate this correlation for future use. This relation in spiral galaxies between rotational velocity and absolute luminosity has been well studied and is typically employed to find distances to galaxies with measured spectra. In studying the TF relation up to a redshift of 1 we can better calibrate it and make it useful for a wider range of observations. Higher redshifts not only correspond to greater distances, but also earlier times. Thus we will also be examining the effects of evolution on spiral galaxies. Through the TF relationship we get an independent distance estimate and a look into kinematic evolution of these galaxies. Our sample of 10 galaxies has already been photometrically observed and fully reduced. However, since the TF relationship requires kinematic information, we are requesting 4 nights on the 4m to do spectroscopy on each galaxy. With this spectroscopic data, we will complete our study and determine the effects of redshift on the TF relationship.

Summary of observing runs requested for this project

Run	Telescope	Instrument	No. Nights	Moon	Optimal months	Accept. months
1	KP-4m	Spectrograph 1	4		Sep - Nov	Sep - Nov
2						
3						
4						
5						
6						

Scheduling constraints and non-usable dates *(up to four lines)*.

Scientific Justification *Be sure to include overall significance to astronomy. For standard proposals limit text to one page with figures, captions and references on no more than two additional pages.*

The Tully-Fisher (TF) relationship (Tully & Fisher 1977) is a widely used and powerful tool that relates the intrinsic luminosities and rotational velocities of spiral galaxies. These parameters correlate tightly enough that, with a zero point and slope for the relationship, measurements of rotational velocities can yield estimates for intrinsic luminosities. A distance to the spiral galaxy can be obtained by comparing this intrinsic luminosity with an observed apparent magnitude. Since independent estimates of distance are few, this relationship provides an important means for studying galaxies. It is not simply a rule of thumb, though, as it has a clear physical basis. In spiral galaxies the stars are orbiting the center, and maintain these orbits due to their motion. This clear and organized rotation supports the galaxy and permits the assumption that the rotational velocity is coupled with the dynamical mass, that is, the mass of the stars that are orbiting in the galaxy. These stars also have some mass to light ratios, which correlate the estimate of mass with an estimate of light emitted from that mass. The TF relationship is the combination of these two connections: a measure of rotational velocity provides an estimate of luminosity.

As mentioned, this relationship has to be calibrated. These calibrations have been done on nearby galaxies where the distance is known through other means (i.e. Cepheid or Supernova), and the zero point and slope are applied to more distant galaxies to derive their distances (Pierce & Tully 1992). When this relationship is extended to spiral galaxies at increasing redshifts, the slope and zero point begin to change. There are many effects which lead to these changes, but the most significant is that higher redshift galaxies are generally less evolved than present day galaxies. Bohm et al. (2004) finds that the TF slope gets shallowed at $z \sim 0.5$, and accounts for this by a changing mass to light ratio as a galaxy evolves. Galaxies observed in other environments (cluster vs. field) as well as galaxies with unusual dynamic histories will also result in a different TF slope.

In order to better study the effects of redshift on the TF relation, we have obtained high quality optical imaging for 10 galaxies with redshifts between 0 and 1.1. We have derived the necessary inclination angles (to correct for projected rotation velocity) and apparent magnitudes (Janowiecki 2007). All that remains is to obtain a spectrum for each galaxy in order to compute its rotation velocity. While this computation is a well-established procedure for nearby galaxies, it becomes a more complicated problem at high redshifts where the galaxies are quite small on the sky. Chiu et al (2007) obtained similar spectra and Figure 1 shows some of their imaging and spectral data for reference. The spectral data is processed with a routine developed by Simard & Pritchet (1998) called ELFIT2D. It creates synthetic emission line models and guesses at rotation curves until the observed spectra is reproduced. This technique has been successfully applied in similar data sets (Chiu et al 2007). These rotation curves asymptote (or have their maximum at) the value we use for rotation velocity. The computed spectra will also permit us to derive redshifts for the sample, providing another distance measure and allowing us to look for redshift trends in the TF relation. Bamford et al. (2006) has undertaken a similar study of TF slope as a function of redshift, and their results are unable to make a claim about any redshift dependence (Figure 2). We expect our results to have smaller error and to more tightly constrain the TF relationship at high redshifts, in order to make a stronger statement about the TF slope's dependence of redshift. Our calibration of the TF slope and zero point will not only serve as a tool for future use in distance estimates at high redshift, but it will also reveal fundamental properties of the kinematics of evolving spiral galaxies.

Figure 1: Imaging and spectral observations of similar galaxies to those in this proposal. Columns: (a) optical image, (b) modelled galaxy, (c) model-subtracted, (d) observed spectra, (e) best fit synthetic model. The optical images are 12" x 12". Both spectra are 9" (25 Å) across and contain the flux at the 3727 Å[OII line] best fit. While they are not identical to traditional rotation curves, the kinematic information can still be extracted from them. These galxies are at redshifts around 0.8. (Chiu et al. 2007, Figure 2)

Figure 2: TF slope as a function of (binned) redshift. While this graph does not show a significant trend over redshift, our observations will have improved sensitivity and less uncertainty. (Bamford et al. 2006, Figure 6b)

References

Bamford, S. P., Aragn-Salamanca, A.,Milvang-Jensen, B., 2006, MNRAS, 366, 308

Bohm, A., et al. 2004, A&A, 420, 97

Chiu, K., Bamford, S. P., Bunker, A., 2007, MNRAS, 377, 806

Janowiecki, S. P., 2007, private communication

Pierce, M. J., Tully, R. B., 1992, ApJ, 387, 47

Simard L., Pritchet C.J., 1998, ApJ, 505, 96

Tully R. B., Fisher J.R., 1977, AAP, 54, 661

Observing Run Details for Run 1: HET/LRS

Technical Description *Describe the observations to be made during this observing run. Justify the specific telescope, the number of nights, the instrument, and the lunar phase. List objects, coordinates, and magnitudes (or surface brightness, if appropriate) in the Target Tables section below (required for queue and Gemini runs).*

The targets for this observation are 10 galaxies from the DEEP2 spectroscopic survey (Cuillandre et al 2001), following the selection criteria of Chiu et al (2007). They are inclined enough to prevent most of the interference from dust, but not inclined so much as to alter the inclination correction (from projection) to the rotation velocity measurement. These galaxies are at redshifts between 0.77 and 1.1, with apparent I-band magnitudes from 21 to 21.6, and angular sizes between 2 and 4 arcseconds. In order to obtain a S/N of $\sim$ 10, we will expose for 3 hours on each galaxy, using Setup 2 on the spectrograph.

Cullandre, J.-C. et al., 2001, in Clowes R., Adamson A., Bromage G., eds, ASP Conf. Ser. Vol. 232, The New Era of Wide Field Astronomy. Astron. Soc. Poc. San Francisco, p. 398

Instrument Configuration

Filters:	Slit: 1”	Fiber cable:
Grating/grism:	Multislit:	Corrector:
Order:	λ_{start}:	Collimator:
Cross disperser:	λ_{end}:	Atmos. disp. corr.: