GLOBAL LINE PROFILE ASYMMETRIES IN DISK GALAXIES

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Abstract We study the global line profiles of 39 disk galaxies with H I and H II data. We find good agreement between the first and second moments of the profiles and recession and rotation velocities, respectively. The shapes of H I and H II profiles differ markedly, however, as the line profile asymmetries are not correlated. Asymmetry in neither H I nor H II profiles is correlated with rotation curve asymmetry which suggests that differing distributions of gas, and not kinematic asymmetries, dominate the global profile asymmetries of normal disk galaxies.

1. Introduction

Despite the limitation that global line profiles, like those obtained from single dish H I observations, provide no spatial information, they do contain a wealth of information about disk galaxies and have been used to map out large scale structure, develop the Tully-Fisher scaling relation and establish that a large fraction of disk galaxies are asymmetric.

Kinematic asymmetries were first noted in H I velocity fields (Baldwin, Lynden-Bell & Sancisi 1980). Richter & Sancisi (1994), using the asymmetry index as defined by Tifft & Cocke (1989), first established that ∼50% of disk galaxies have asymmetric H I line profiles. They conjectured that since some of the galaxies with asymmetric line profiles were disturbed optically, that line profile asymmetry was most likely due to kinematic asymmetries. Since then, different methods have been developed for measuring line profile asymmetry, but results have been similar (c.f. Haynes *et al.* 1998). The large fraction of asymmetric galaxies implies that these asymmetries are long-lived. However, evidence suggests photometric and kinematic asymmetries may not be related to global profile asymmetries (cf. Verheijen 1997, Swaters 1999 *et al.*).

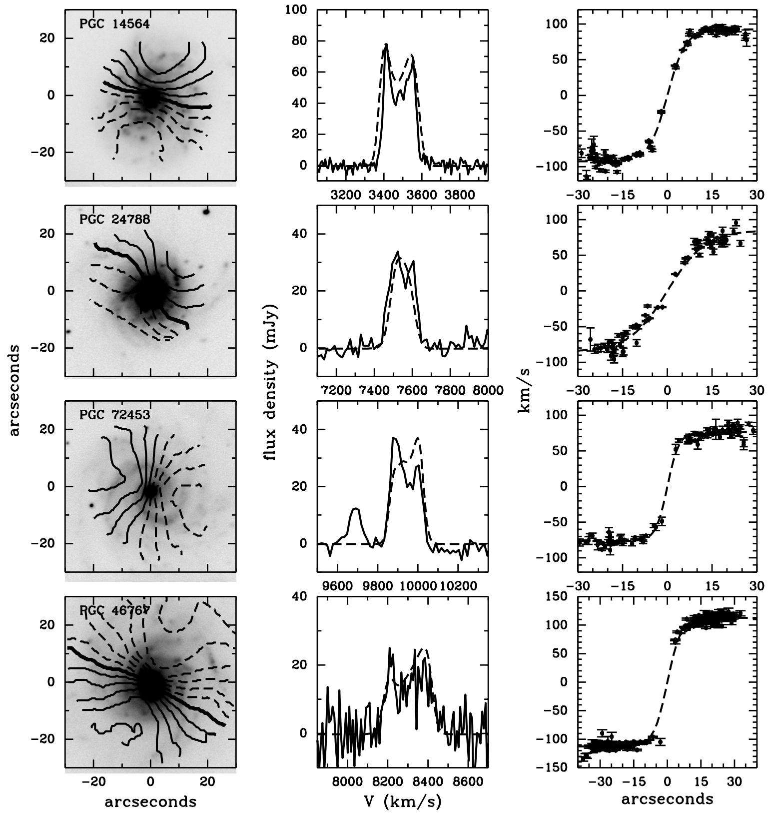

Figure 1. **Left Panels:** Velocity fields of four galaxies. **Central Panels:** H I(dashed) and H II(solid) profiles scaled to the radio flux. **Right Panels:** Rotation curves extracted from the Hα data. Asymmetries in the rotation curves are not usually apparent in the profiles.

Here, we compare moments obtained from H I and H II global line profiles and show that these moments are precise and accurate measures of recession velocities, linewidths, and asymmetries. We then explore on the differences between the H I and H II asymmetries in our sample and comment on the physical causes of line profile asymmetries.

2. Data

Hα integral field spectroscopy was obtained for 39 nearby, nearly face-on disk galaxies using DensePak. From this data we created integrated Hα linewidth profiles. H I line profiles for 25 of these galaxies were observed using the Nançay radio telescope. The reduction and basic analysis of these H I and H II data are presented in Andersen *et al.* (2005). The lower signal to noise of the H I data, combined with some

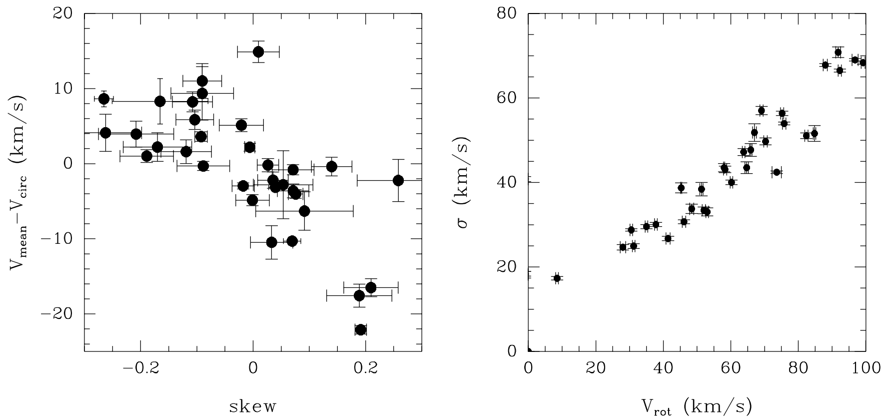

Figure 2. **Left Panel:** The difference between recession velocities measured from profiles and velocity field modeling are strongly correlated with skew, implying the third moment can improve estimates of the first. **Right Panel:** The second moment, σ, is highly correlated with the modeled recession velocity, V_{rot}. Only at low recession velocities do the two quantities deviate due to the intrinsic Hα linewidth.

bad baseline determinations mean that we were only able to measure H I linewidths for 14 of these galaxies. We also constructed and modeled the Hα velocity field data to find rotation and recession velocities and rotation curve asymmetries (Andersen *et al. in preparation*). Four examples of the Hα velocity fields, Hα and H I global line profiles and Hα rotation curves are shown in Figure 1.

3. Line Profile Moments and Asymmetries

We have shown that a moments analysis is a simple, accurate and precise alternative method of extracting recession velocities, velocity widths and asymmetry from line profiles (Andersen & Bershady 2005). Figure 2 shows that the first moment is a good surrogate for velocity-field modeled recession velocity (especially if the third moment, skew, is used to correct the first moment), and the second moment, σ, is strongly correlated with disk rotation velocity.

The third moment, skew, is highly correlated with other measures of line profile asymmetry (Figure 3). Roughly half our sample showed significant asymmetries consistent with Richter & Sancisi (1994), but surprisingly, the H I and H II skew measures were decidedly un-correlated. Since the H I gas is present at much larger radii, the non-correlation of asymmetry suggests that the difference is either related to kinematic asymmetries present at different physical scales, or that the distribution of H I and H II phases differ significantly. To shed light on this question, we studied the kinematic asymmetries of the Hα rotation curves. Neither

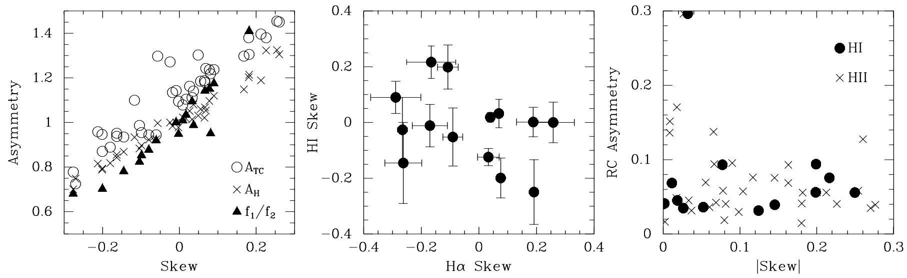

Figure 3. **Left Panel:** Skew is highly correlated with the ratio of peak fluxes and asymmetries as measured by Haynes et al. (1998) and Tifft & Cocke (1988). **Central Panel:** Skew measured from H I and H II profiles may be anti-correlated, one hint that the shape of the profiles is more closely related to differences in the distribution of the gas than to kinematic asymmetries. **Right Panel:** Skew is not correlated with rotation curve asymmetry (Dale et al. 2001); skew does not appear to measure kinematic asymmetry for normal disk galaxies.

H I nor H II profile asymmetries are correlated with rotation curve asymmetry, which suggests that asymmetries in the global profiles are not related to kinematic asymmetries.

4. Summary

A moment analysis of 39 normal, nearly face-on disk galaxies with global H I and H II profiles shows that the first and second moments are correlated with recession and rotation velocities respectively. Even better estimates of recession velocities can be made from the first moment if the third moment, skew, is considered as well. Skew is highly correlated with measures of global profile asymmetry. Skew measured for H I and H II global line profiles are uncorrelated, which suggests that the distribution of the different phases of hydrogen gas, not kinematic asymmetries, is responsible for most global profile asymmetries. Further supporting evidence for this theory is that global line profile asymmetries are uncorrelated with asymmetries in the Hα rotation curves.

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