INTERNAL KINEMATICS OF LUMINOUS COMPACT BLUE GALAXIES

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Abstract We describe the dynamical properties which may be inferred from HST/STIS spectroscopic observations of luminous compact blue galaxies (LCBGs) between $0.1 < z < 0.7$. While the sample is homogeneous in blue rest-frame color, small size and line-width, and high surface-brightness, their detailed morphology is eclectic. Here we determine the amplitude of rotation versus random, or disturbed motions of the ionized gas. This information affirms the accuracy of dynamical mass and M/L estimates from Keck integrated line-widths, and hence also the predictions of the photometric fading of these unusual galaxies. The resolved kinematics indicates this small subset of LCBGs are dynamically hot, and unlikely to be embedded in disk systems.

Keywords: LCBGs, STIS Spectroscopy, Internal Kinematics, Dynamics, Evolution

1. Introduction

The evolution of LCBGs is a matter of debate. These galaxies are unusual in their blue colors, small sizes and line-widths, yet large luminosities. We have suggested that at least a subset of these sources are the progenitors of dEs such as NGC 205 (Koo et al. 1995, Guzman et al. 1998), while others counter these are bulges in formation (Hammer et al. 2001; Barton & van Zee 2001). Surveys at intermediate redshift are not uniformly defined, and each contains heterogeneous samples – objects span a range in size, color, luminosity, surface-brightness, and image concentration. The broad "LCBG" class contributes as much as 45% of the comoving SFR between $0.4 < z < 1$ (Guzman et al. 1997); the proposed dE progenitors are a fraction of this class. Here we focus on an extreme LCBG sub-class that are among the smallest, bluest and highest surface-brightness (Koo et al. 1995): $M_B \sim -21$ (H_0=70 km/s/Mpc, Ω=1, Ω_Λ=0.7), rest-frame B-V$\sim$0.25, half-light radii of $R_e \sim$2 kpc, mean surface-brightness within R_e of $\sim$19 mag/arcsec^2 (rest-frame B band), and integrated line-widths of $\sigma_{gas} \sim$65 km/s. Many of these are good candidates for dE progenitors. If so, their internal kinematics should reveal they are dynamically hot, while deep imaging should show they lack outer disks.

2. STIS Spectra: Are LCBGs Dynamically Hot or Cold?

We have derived ionized-gas position–velocity and position–line-width diagrams from STIS long-slit measurements along what appears to be the photometric major axes of 6 LCBGs between $0.2 < z < 0.7$, and one other source at $z \sim 0.1$ which is 2-3 mag lower luminosity than the others. One example is given in Figure 1. With 0.2 arcsec slits, STIS delivers instrumental resolutions (σ) of 13-19 km s^{-1}. Line-emission is not always centered on the continuum (Hoyos et al. 2004); the continuum centroid is adopted as the kinematic center.

We find Keck HIRES integrated line-widths (Koo et al 1995) agree in the mean with the resolved velocity dispersions from STIS spectroscopy: Integrated dispersions are not due to large-scale, bulk, motion. This secures our previous dynamical estimates of M/L and their use as constraints on photometric fading (e.g., Guzman et al. 1998). Only the low-L, low-z system shows clear rotation and substantially different integrated versus resolved line-widths.

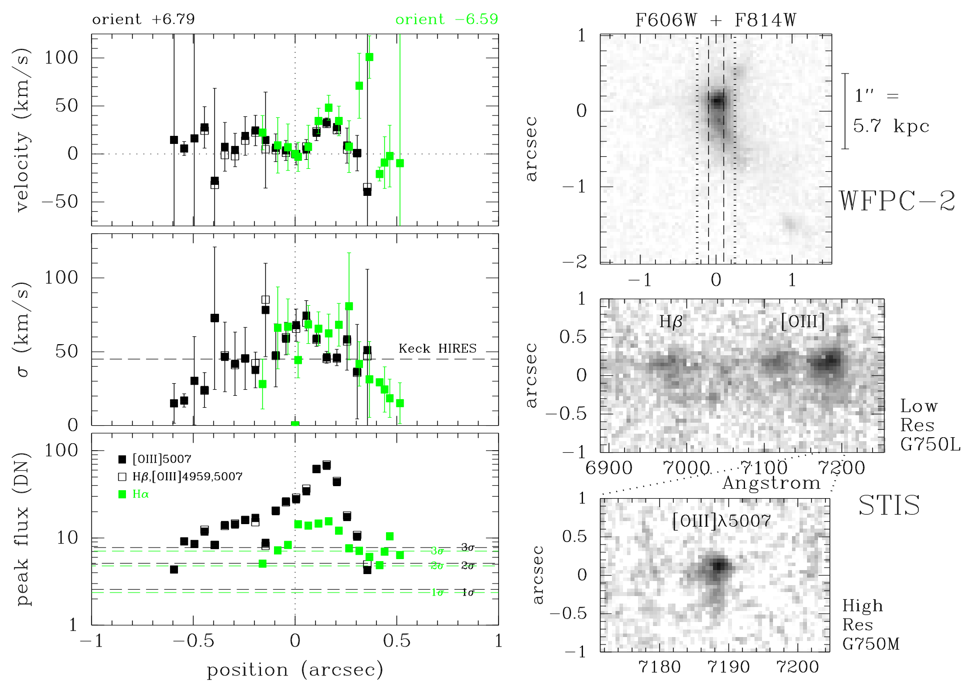

Figure 1. Morphology and kinematics of LCBG 313088 at $z = 0.44$. Left: HST/WFPC-2 image showing distorted, tail-like source morphology and mean STIS slit positions (0.2 and 0.5 arcsec). STIS spectra for low and high-resolution gratings are at bottom. Right: Position vs velocity, line-width, and line-flux for two sets of high-resolution data taken at two position angles varying by $\sim 13^\circ$. (Hα spectrum not shown). Spectral data consistently show extended line-emission with little velocity gradient, no evidence for rotation, and dispersions that agree in the mean with Keck HIRES integrated measurements (dashed line, middle panel).

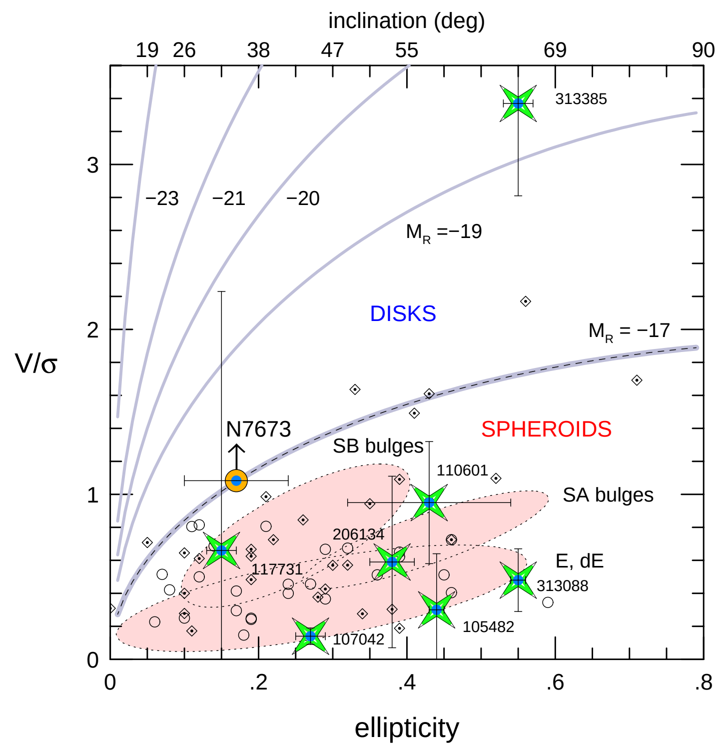

Figure 2. V/σ versus ellipticity or inclination for LCBGs (dotted stars), NGC 7673 (circle/lower limit) and early-types galaxies from Simien & Prugniel (circles, dotted diamonds). Lines represent trajectories as a function of inclination for disk-galaxies of different luminosity assuming they lie on the Tully-Fisher relation and $\sigma_{gas} = 25$ km s^{-1} (Andersen et al. 2005). Shaded regions are adopted from Kormendy & Kennicutt (2004).

The lack of rotation coupled with their ellipticity squarely places these sources in the "spheroidal" region of the V/σ - ellipticity plane, illustrated in Figure 2. For fair comparison to local samples, ellipticities are measured at the half-light radius near rest-frame V-band from HST images; rotation velocities are set to half the difference between minimum and maximum velocities; and σ is the observed central velocity dispersion. While there is a range of observed V/σ, LCBGs lie well below the region inhabited by disk systems, with values comparable to local dEs and other spheroidals, particularly if recent observations of dEs with larger rotational components are considered (Pedraz et al. 2002, van Zee et al. 2004): **LCBGs are dynamically HOT**.

3. Progenitors and Descendants

Do we know that we aren't just sampling a bulge, or a face-on nuclear starburst? NGC 7673 has been suggested by Homeier et al. (2002) as a nearby example. Indeed this source has the right color, surface-brightness, size, luminosity and integrated line-width, and has a faint, extended outer disk. However, Homeier & Gallagher's (1999) Hα velocity map shows clear evidence for rotation in the inner, star-burst region. Our re-analysis confirms this: We would see similar structure *if it existed* in our STIS spectra. Independently, deep CFHT imaging reveals no strong evidence for extended, normal disks around the types of (and specific) sources presented here (Barton et al. 2005).

In summary, the preponderance of evidence is against bulge formation in disk systems and in favor of a dE-like descendant scenario *for all of the specific sample presented here* with $M_B<-20$ (6 out of 7). However, the disturbed morphology and kinematics makes clean interpretations difficult. What is the gas really telling us about dynamics? Are these systems in dynamical equilibrium? While their morphology and resolved kinematics would argue otherwise, the agreement between integrated velocity dispersions and resolved profiles indicates the systems cannot be too far out of equilibrium. Stellar velocity and dispersion profiles would provide a much clearer dynamical picture.

Finally we comment on issues raised at the conference about environment: Is NGC 205 a good example of a faded, LCBG descendant? If so, where are the M31-like neighbors? Are there field dEs? If dSphs are the low-mass cousins of dEs, then the presence of isolated dSphs such as Tucana, Cetus, and the recently discovered Apples 1 (Pasquali et al. 2004) should give us pause about accepting assertions that dEs do not exist outside of rich environments or far from massive galaxies. The space density of LCBGs presented here is $1.25\pm0.15\times10^{-5}$ Mpc^{-3} for $M_B < -20$ between $0.3 < z < 0.7$. Even allowing a factor of ~ 20 higher relic density (given the time interval in this redshift slice and assuming the LCBG phase is a few$\times10^8$ yr) to find even one descendant requires an all-sky local survey volume reaching out to $\sim$10 Mpc. At this distance the half-light radius of NGC 205 is $\sim$12 arcsec. Are our local surveys this complete?

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