Regular Exponential Disks from Irregular Dwarf Galaxies

Deidre Hunter (Lowell Obs), Bruce Elmegreen (IBM T. J. Watson Research Center), Se-Heon Oh (Univ of Western Australia), Ed Anderson (Northern Arizona Univ), Tyler Nordgren (Univ of Redlands), Philip Massey, Nick Wilsey, & Malanka Riabokin (Lowell Obs)

Synopsis

In order to explore the properties of extreme outer stellar disks, we obtained deep *V* and *GALEX* ultraviolet (UV) images of four dwarf irregular galaxies and one Blue Compact Dwarf galaxy, and deep *B* images of three of these. Our *V*-band surface photometry extends to 29.5 mag/arcsec^2. We convert the FUV and *V*-band photometry, along with Hα photometry obtained in a larger survey, into radial star formation rate profiles that are sensitive to timescales from 10 Myr to the lifetime of the galaxy. Our data lead us to two general observations. First, the exponential disks in these irregular galaxies are extraordinarily regular. We observe that the stellar disks continue to decline exponentially as far as our measurements extend. In spite of lumpiness in the distribution of young stars and HI distributions and kinematics that have significant unordered motions, sporadic processes that have built the disks—star formation, radial movement of stars, and perhaps even perturbations from the outside—have, nevertheless, conspired to produce standard disk profiles. Second, there is a remarkable continuity of star formation throughout these disks over time. In three out of five of our galaxies the star formation rate in the outer disk measured from the FUV tracks that determined from the *V*-band, to within factors of five, requiring star formation at a fairly steady rate over the galaxy's lifetime. Outer stellar disks are challenging our concepts of star formation and disk growth and provide a critical environment in which to understand processes that mold galaxy disks.

The Data

Ultra-deep *V* and *B* images were obtained with the Mosaic CCD camera on the KPNO 4m and the KPNO 2.1m. Multiple exposures were obtained and stacked. Total *V* exposure times were 8.5-11.3 hr on the 2.1m and 1.3-2.5 hr on the 4m. The photometry was corrected for reddening using foreground reddening plus 0.05 mag of internal reddening and a Cardelli et al. (1989, ApJ, 345, 245) extinction curve. **Deep NUV and FUV images** obtained with *GALEX* have effective wavelengths of 2267 Å and 1516 Å. Exposure times in FUV were 2.3-3.9 hr. **HI emission maps** were obtained with the VLA. We produced moment maps, fit rotation curves to the velocity field, and deconvolved non-ordered from ordered motions (Oh et al. 2008, AJ, 136, 2761).

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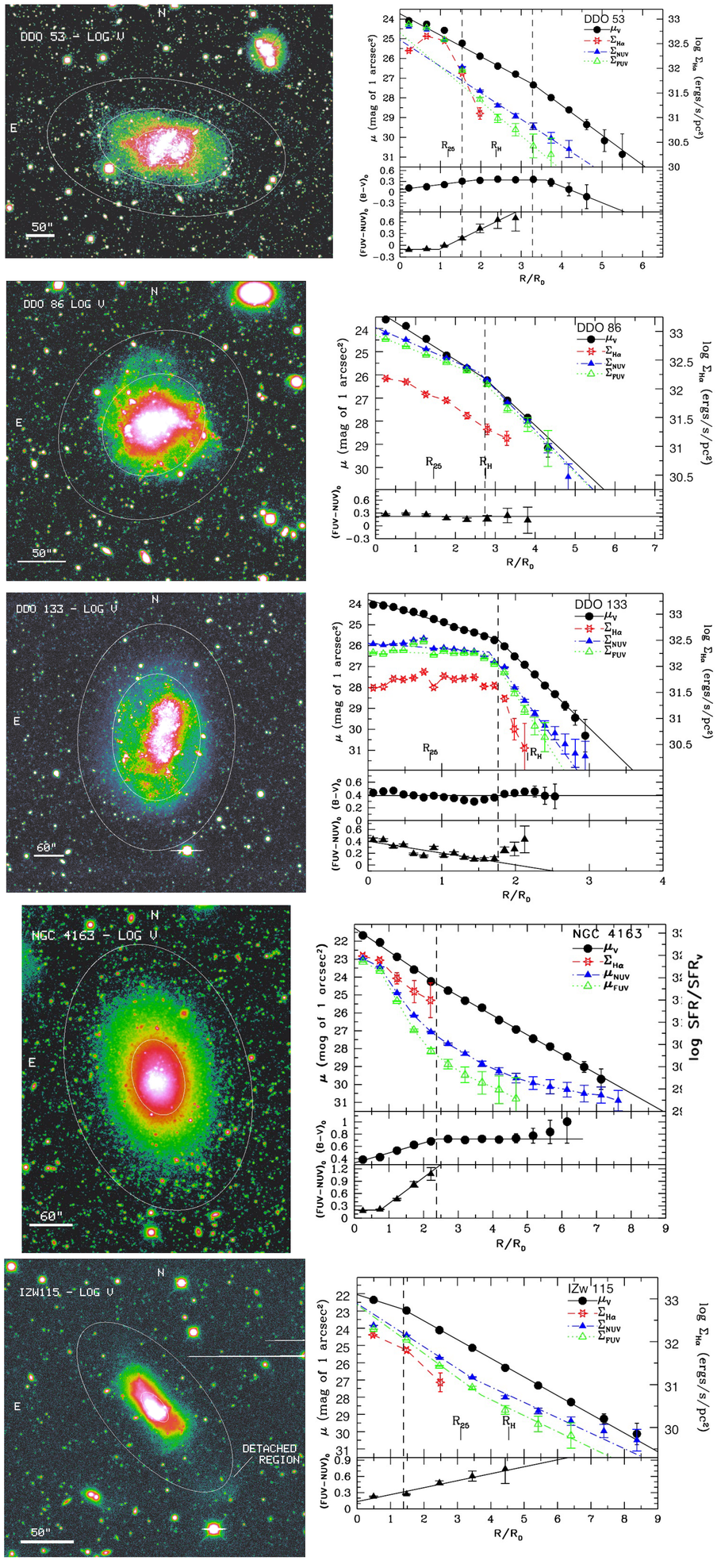

Figure 1: Left: False-color log *V*-band images. The white ellipses show the breaks in the surface photometry and the outer-most ellipse that was used in the surface photometry. **Right:** Azimuthally-averaged surface photometry and colors corrected for reddening, plotted against radius from the galaxy center normalized to the disk scale-length R_D. The dashed vertical line marks the break in the *V*-band profile.

The Edges of the Stellar Disks

The *V*-band surface photometry extends to 29.5 mag/arcsec^2. We have not observed the edges of the stellar disks.

Exponential Outer Disks

All 5 galaxies have exponential disks as far as they are traced. All have a break in their profiles; 4 bend down in the outer disk and one (NGC 4163) bends up.

Star Formation Histories

A surface brightness of 29.5 mag/arcsec^2 at DDO 133 corresponds to a stellar density of 0.06 M_o/pc^2. The star formation rate (SFR) there is 0.00001 M_o/yr/kpc^2 or about 6 Orion Nebulae over an area of 40 kpc^2 on average at any given moment. In the outer disks, star formation is currently depressed in DDO 53 and NGC 4163 compared to that in the past, while the other three galaxies have roughly constant SFRs.

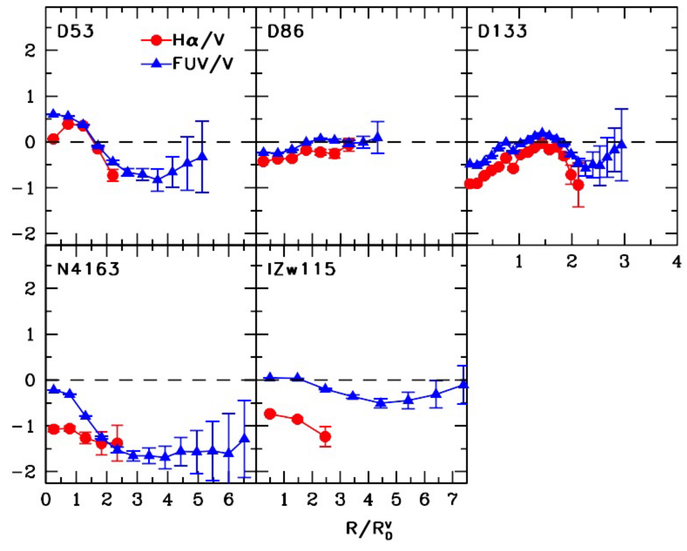

Figure 2: Azimuthally-averaged SFRs: FUV (timescale ~ 100-200 Myr) and Hα (timescale ~ 10 Myr), divided by the *V*-band (timescale ~ lifetime) derived SFR. The horizontal dashed line marks equal SFRs. Radius is normalized to the disk scale length R_D determined in the *V*-band.

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