Stellar Surface Brightness Profiles: Dwarfs to Spirals

Kimberly Herrmann (Penn State Mont Alto), LITTLE THINGS Team

ABSTRACT

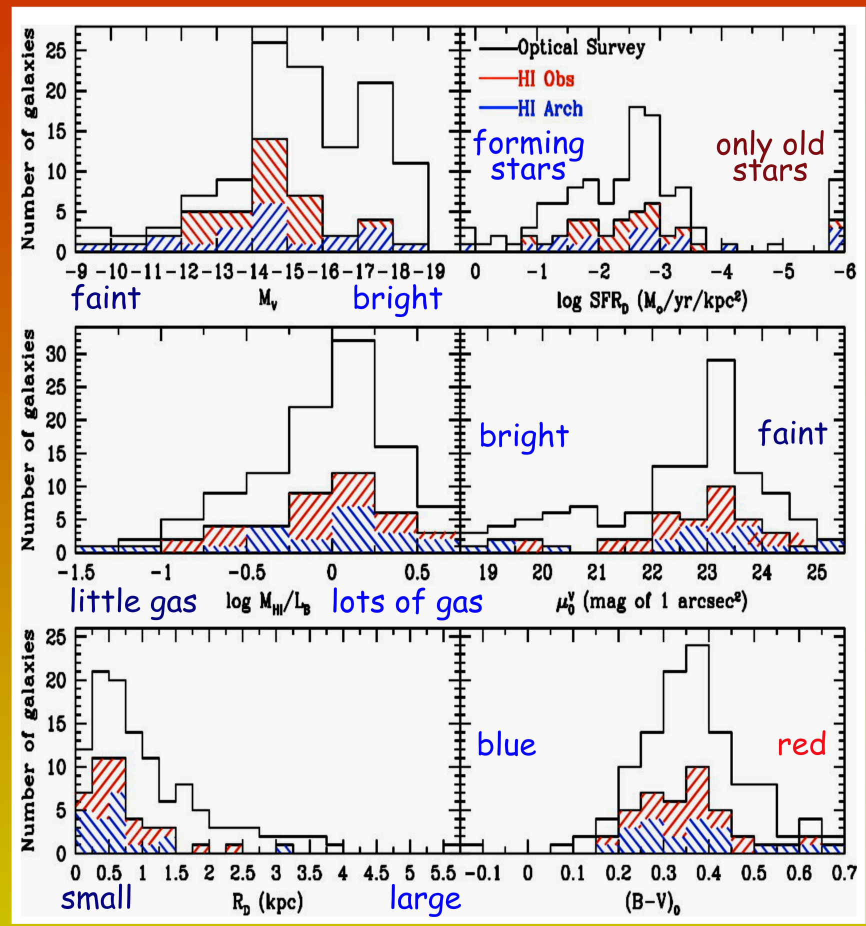
Radial stellar surface brightness profiles of spirals are classified into three types: (I) single exponential, or the light falls off with one exponential to a break radius and then falls off (II) more steeply, or (III) less steeply. Why there are three types is still a mystery, including why light falls off as an exponential at all. Profile breaks are also found in simpler dwarf irregulars. This poster highlights results from a semi-automatic fitting of a multi-wavelength data set of 141 dwarfs [1-6] including: (1) statistics of break locations and other properties as a function of wavelength and profile type that reveal strong trends from tiny dwarfs through spirals [7, Paper I], (2) color trends and radial mass distribution as a function of profile type [8, Paper II], and (3) the relationship of the break radius to the kinematics and density profiles of atomic hydrogen gas in the 40 LITTLE THINGS [9] dwarfs [10].

A Riddle:

Look at a galaxy! Its disk light
Falls exponentially- is that right?
If you look deeply, often you'll see
Signs of us- in both Types II and III!
Why do we exist? Explore the gas,
Motions near and far. Profile the mass.
Search with care; do whatever it takes.
We are Surface Brightness Profile Breaks!

1. The Dwarf Sample

- 141 Dwarfs! (parent sample for LITTLE THINGS [9])
  - 96 dIms
    - Dwarf irregular galaxies
  - 26 BCDs
    - Blue Compact Dwarfs
    - Similar to dIms, but with central concentrations of gas, stars, and star formation (SF)
  - 19 Sms
    - Transition between spiral and irregular galaxies
  - Relatively nearby
    - < 90 Mlyr
  - Not obviously interacting
  - With HI gas for possible SF

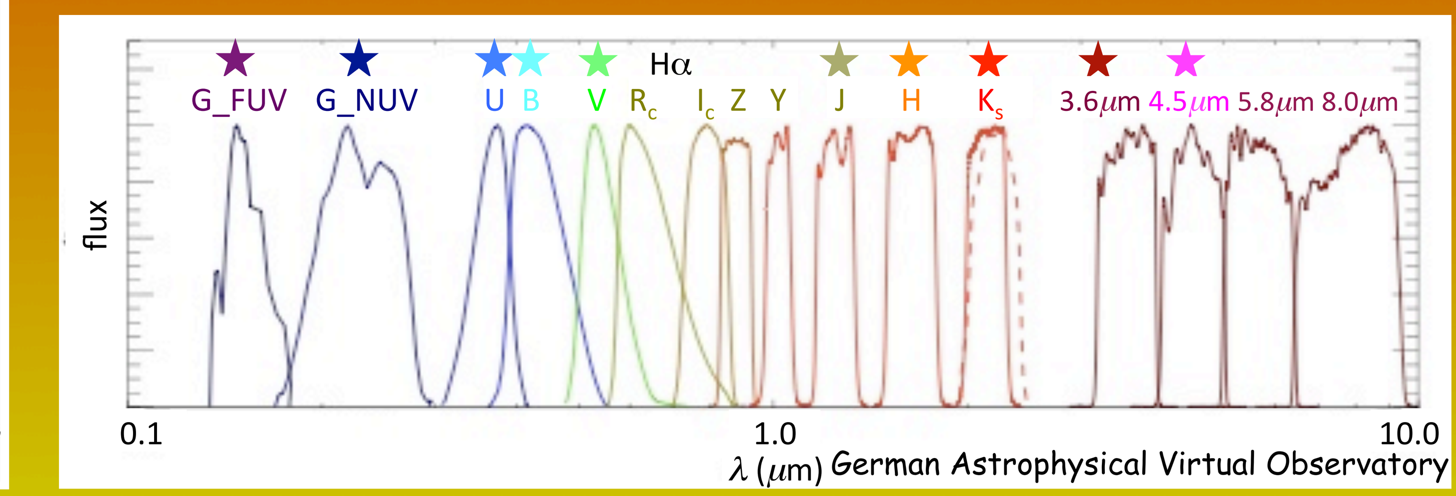


2. Multi-wavelength Data Set

- Up to 11 passbands (776 profiles!)
  - *GALEX* FUV and NUV } Trace most recent SF (200 Myrs)
  - Ground based Hα }
  - Ground based UBV → Dominated by past Gyr of SF
  - Ground based JHK → Integrates SF over galaxy life
  - *Spitzer* 3.6 & 4.5 μm → Old stars, dust, embedded SF

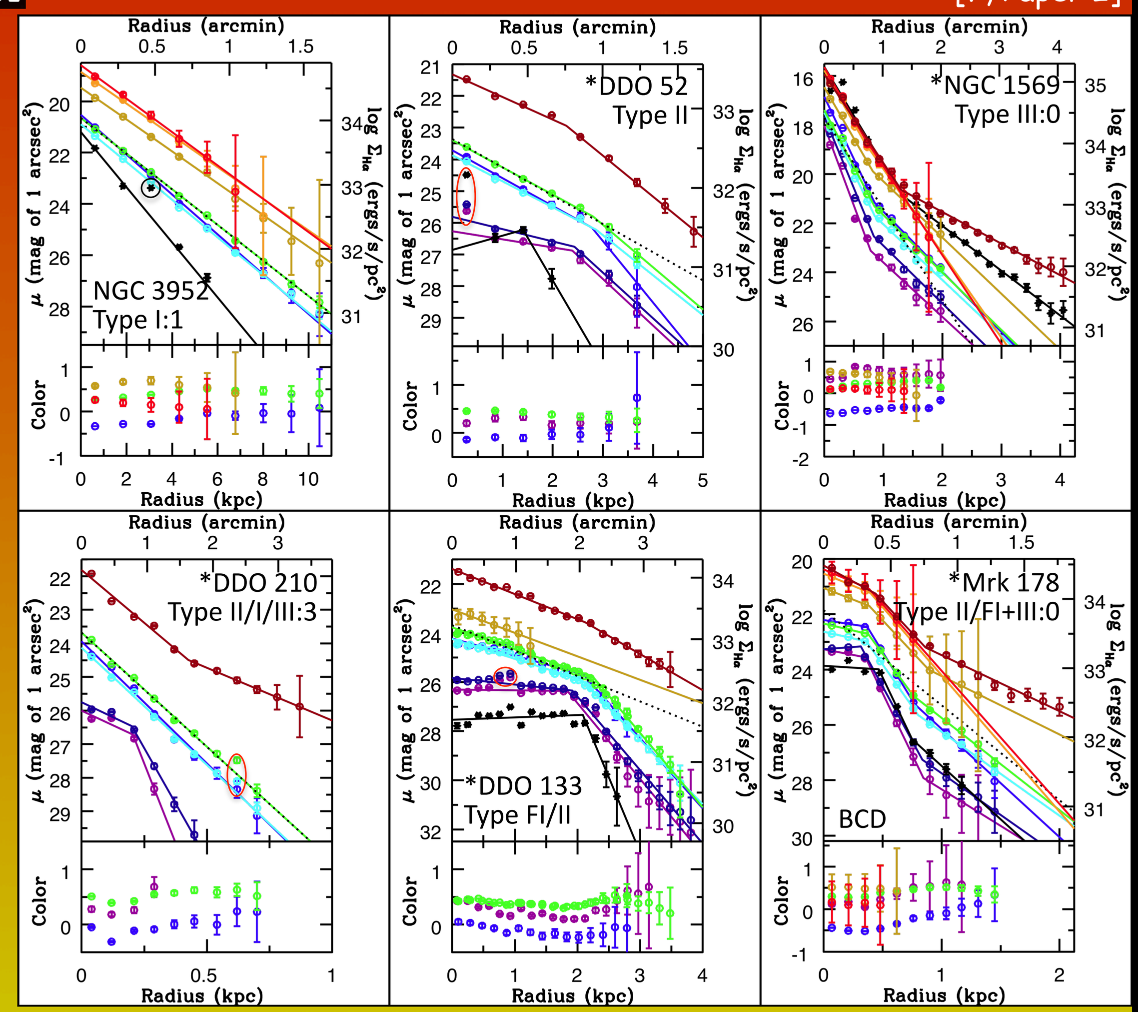
μ	Color
FUV	FUV – NUV
NUV	
U	U – B
B	
V	B – V
Hα	
J	J – H
H	
K	H – K
3.6 μm	3.6 μm – 4.5 μm
4.5 μm	

[1-6, + Spitzer Legacy projects)

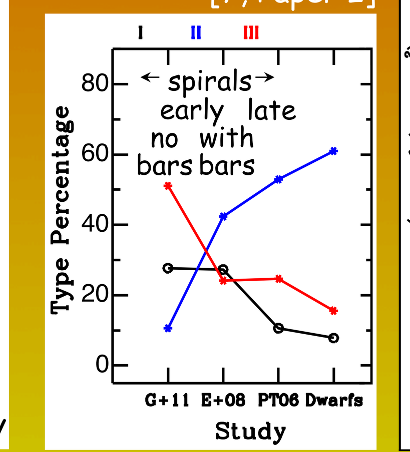


3. Fitting the Data

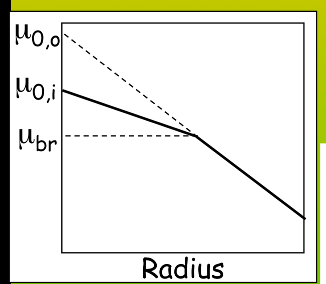
[7, Paper I]



[7, Paper I]



4. $\mu_{0,i}$, $\mu_{0,o}$, & μ_{br} Trends with M_B

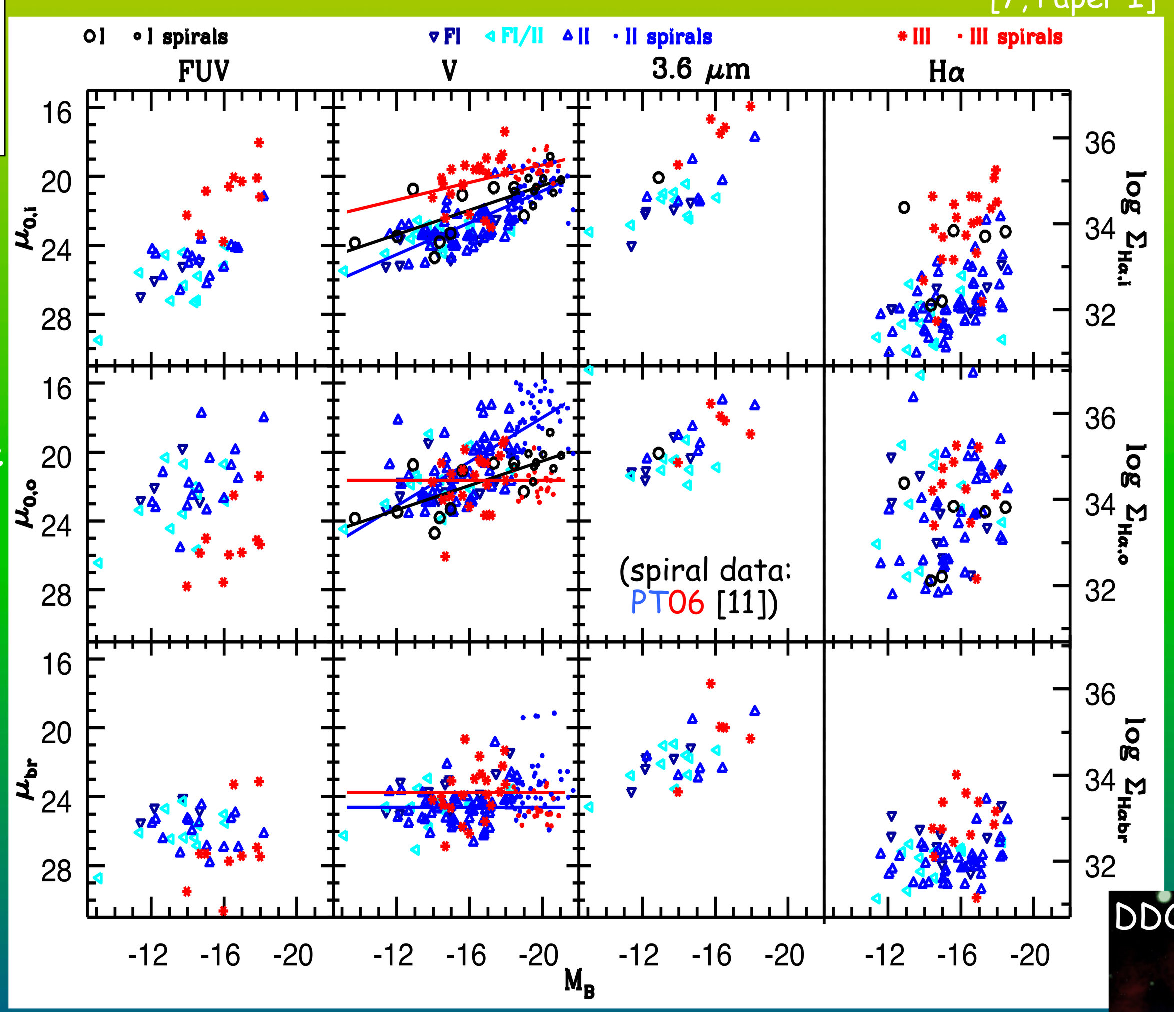


Central Surface Brightness $\mu_{0,i}$ (inner fit)

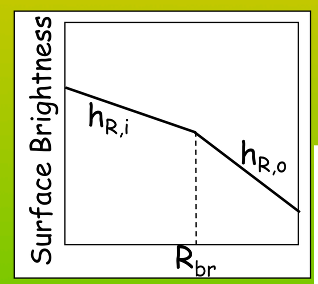
Outer Surface Brightness Projected to Center, $\mu_{0,o}$

Surface Brightness at Break, μ_{br}

[7, Paper I]



5. $h_{R,i}$, $h_{R,o}$, & R_{br} Trends with M_B

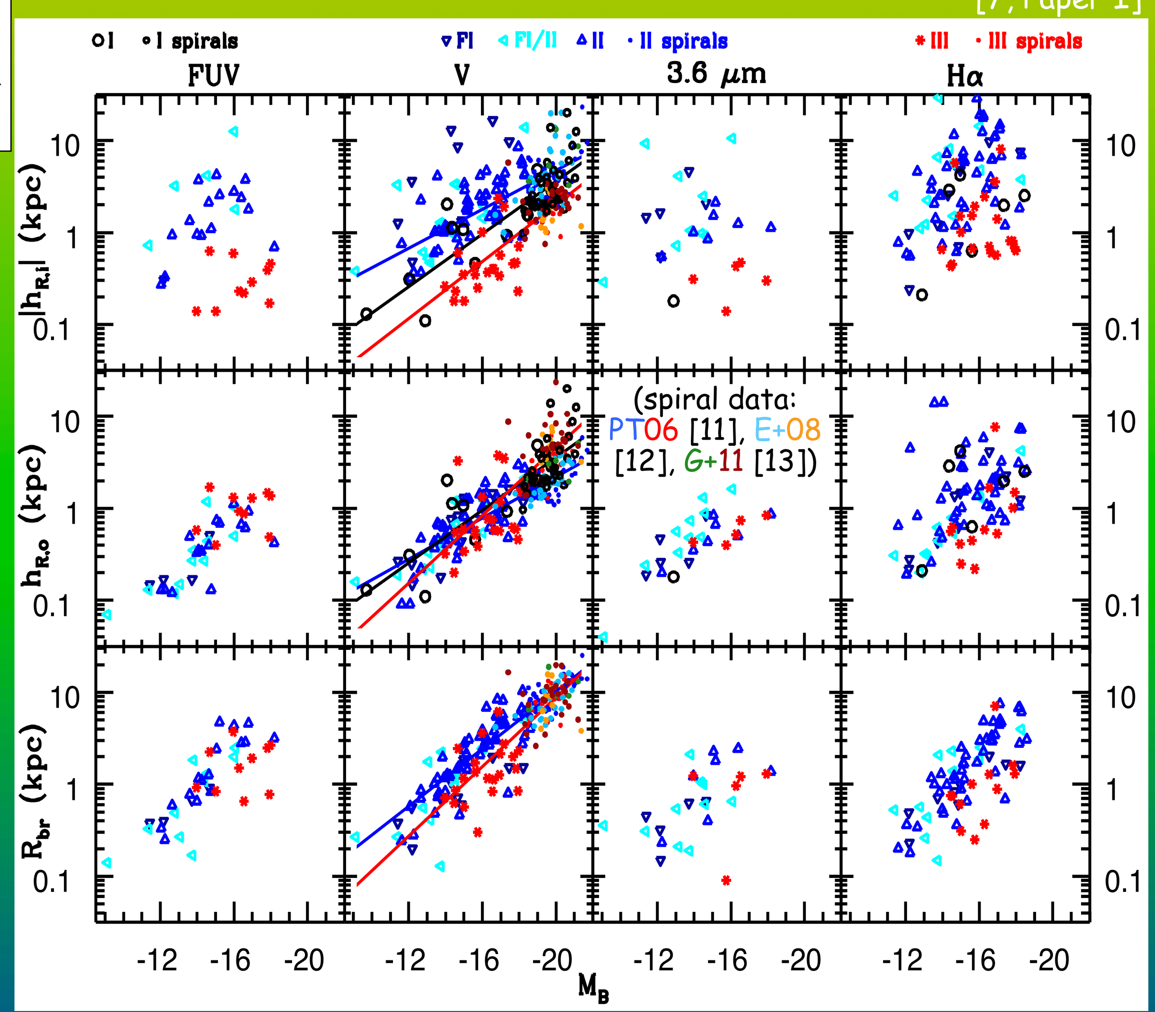


|Inner scale length| $h_{R,i}$ (kpc)

Outer scale length $h_{R,o}$ (kpc)

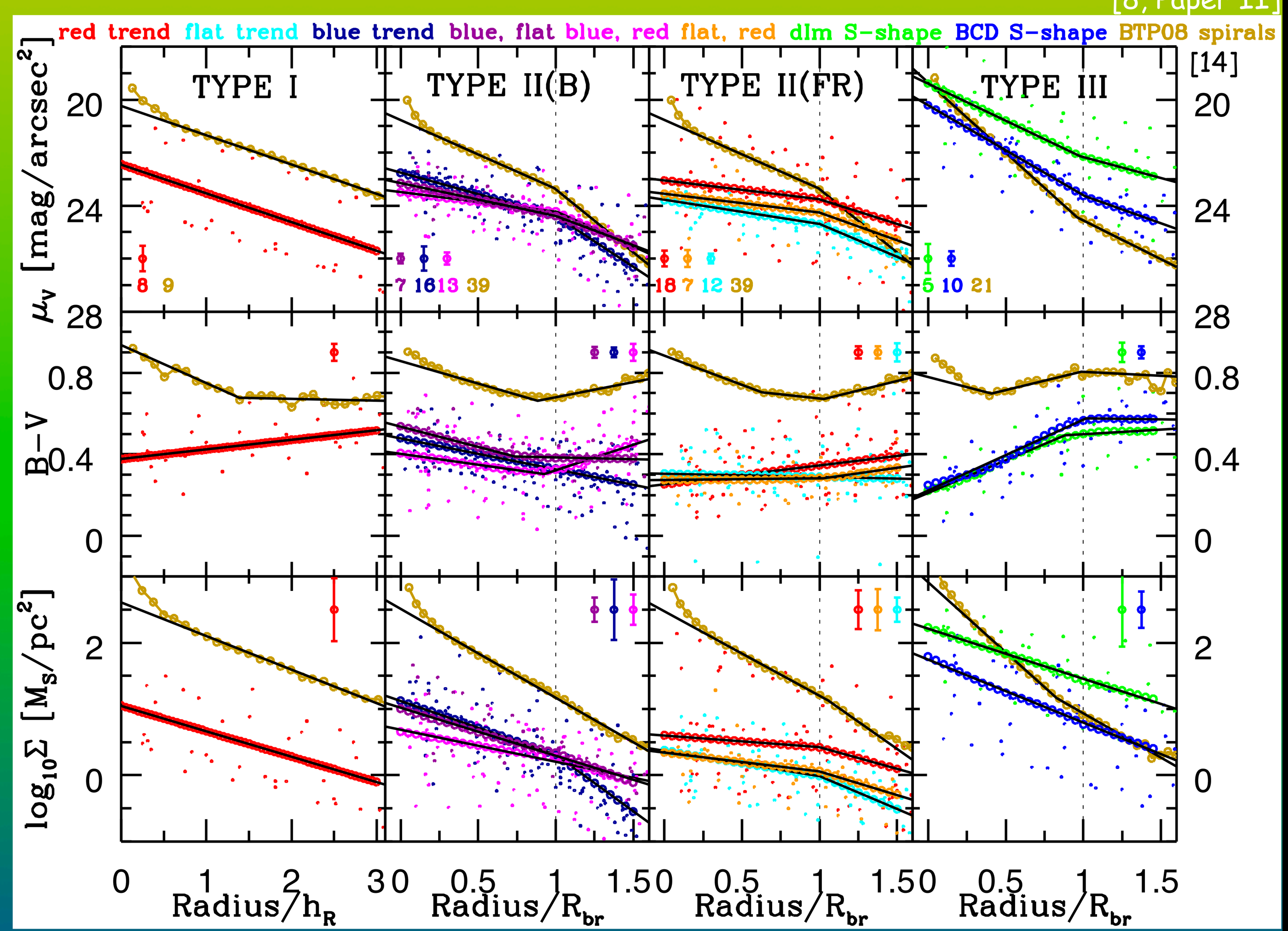
Break location R_{br} (kpc)

[7, Paper I]



6. Radial Color Trends in B-V

[8, Paper II]

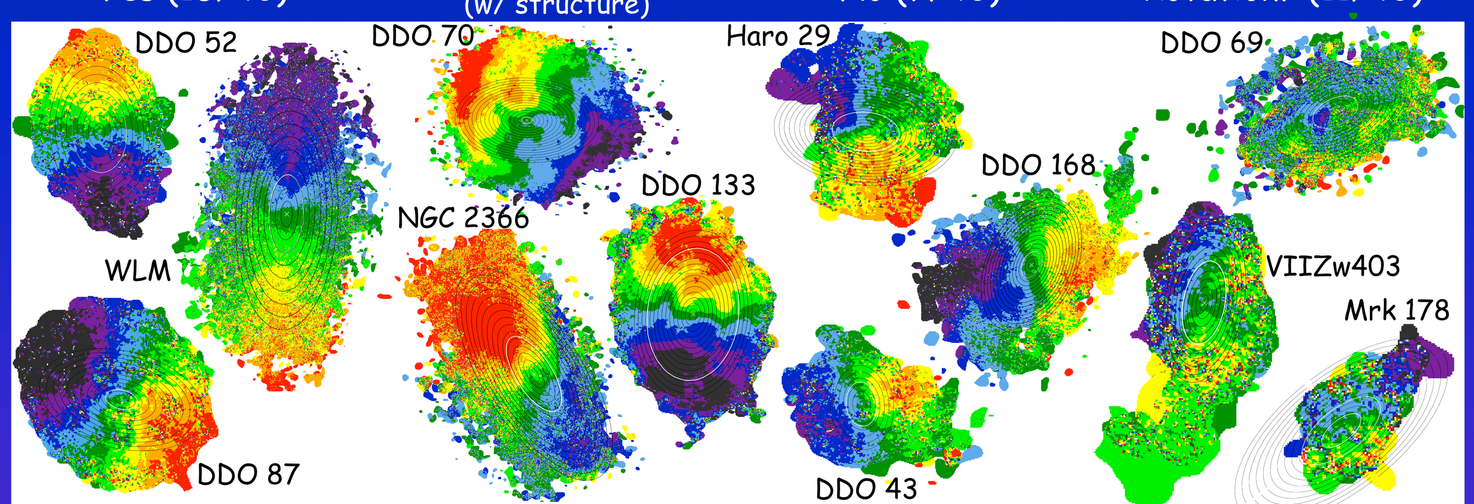


NGC 3738

7. Breaks & LT HI Analysis

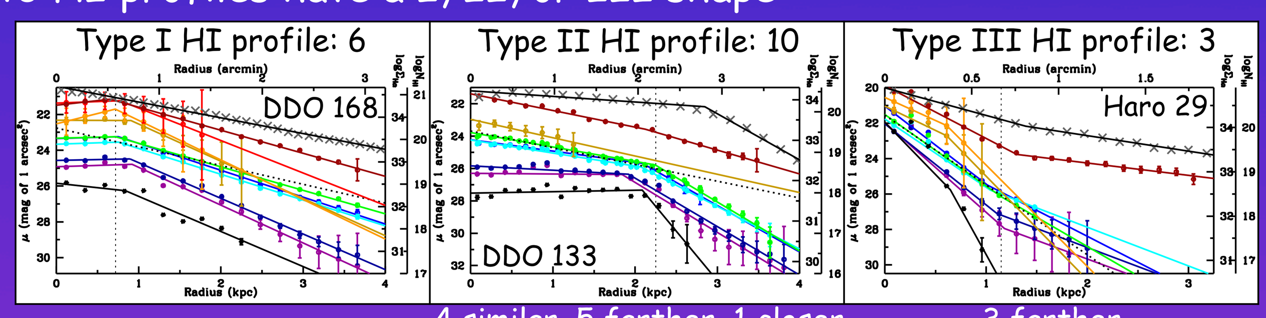
Are the optical & kinematic axes aligned? [10, Paper III, in prep.]

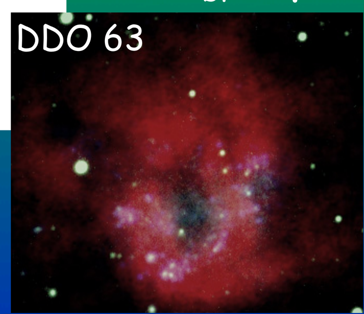
Yes (15/40) Yes (7/40) (w/ structure) No (7/40) Rotation? (11/40)



21/40 HI profiles have a FI shape: 5 similar, 12 farther, 4 closer

19/40 HI profiles have a I, II, or III shape:





DDO 63

8. Some Take Away Points

From Paper I [7, Profiles and Statistics]:

- Dwarfs extend Profile Type trends w/ Hubble type (early: IIIs, late: IIs)
- Many trends in SB fit parameters: M_B = -9 dwarfs to M_B = -21 spirals
- Some parameters constant over that range (μ_{br} ~ 24 mag/arcsec^2 in V)
- Interesting λ trends in dwarfs; multi-λ studies needed for spirals!
- Overall: Inner *depletion* trend in IIs vs. inner *accretion* trend in IIIs?

From Paper II [8, Color Trends and Mass Profiles]:

- Type III dwarf color radial profiles fairly similar to those of spirals
- Type II dwarfs: come in many more flavors than the BR "U" of spirals!

Σ break: reduced in Spiral IIs, remains in Spiral IIIs
reduced/remains in Dwarf IIs, reduced in Dwarf IIIs

We determined new M/L vs. Color relationships for dwarfs [15]

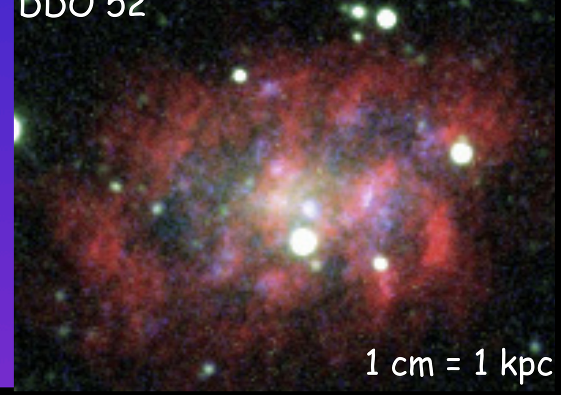
Paper III: What do HI kinematics & density tell about profile breaks?

- Optical & kinematic axes: 55% aligned, 17.5% not aligned, 27.5% unclear rotation
- HI profiles: 52.5% FI, 25% Type II, 15% Type I, and 7.5% Type III

References

[1] Hunter, D.A., & Elmegreen, B.G. 2004, ApJ, 128, 2170
[2] Hunter, D.A., & Elmegreen, B.G. 2006, ApJSS, 162, 49
[3] Hunter, D.A., Elmegreen, B.G., & Martin, E. 2006, AJ, 132, 801
[4] Hunter, D.A., Elmegreen, B.G., & Ludka, B.C. 2010, AJ, 139, 447
[5] Hunter, D.A., Elmegreen, B.G., Oh, S.-H., et al. 2011, AJ, 142, 121
[6] Zhang, H.-X., Hunter, D.A., Elmegreen, B.G., et al. 2012, AJ, 143, 47
[7] Herrmann, K.A., Hunter, D.A., & Elmegreen, B.G. 2013, AJ, 146, 104 (I)
[8] Herrmann, K.A., Hunter, D.A., & Elmegreen, B.G. 2016, AJ, 151, 145 (II)
[9] Hunter, D. A., Ficut-Vicas, D., et al. 2012, AJ, 144, 134
[10] Herrmann, K.A., et al. in prep (Paper III)
[11] Pohlen, M., & Trujillo, I. 2006, A&A, 454, 759
[12] Erwin, P., Pohlen, M., & Beckman, J.E. 2008, AJ, 135, 20
[13] Gutiérrez, L., Erwin, P., Aladro, R., & Beckman, J.E. 2011, AJ, 142, 145
[14] Bakos, J., Trujillo, I., & Pohlen, M. 2008, ApJ, 683, L103
[15] Herrmann, K.A., Hunter, D.A., Zhang, H.-X., & Elmegreen, B.G. 2016, AJ, 152, 177

DDO 133



DDO 52

1 cm = 1 kpc