The emergence of Low Surface Brightness Galaxies

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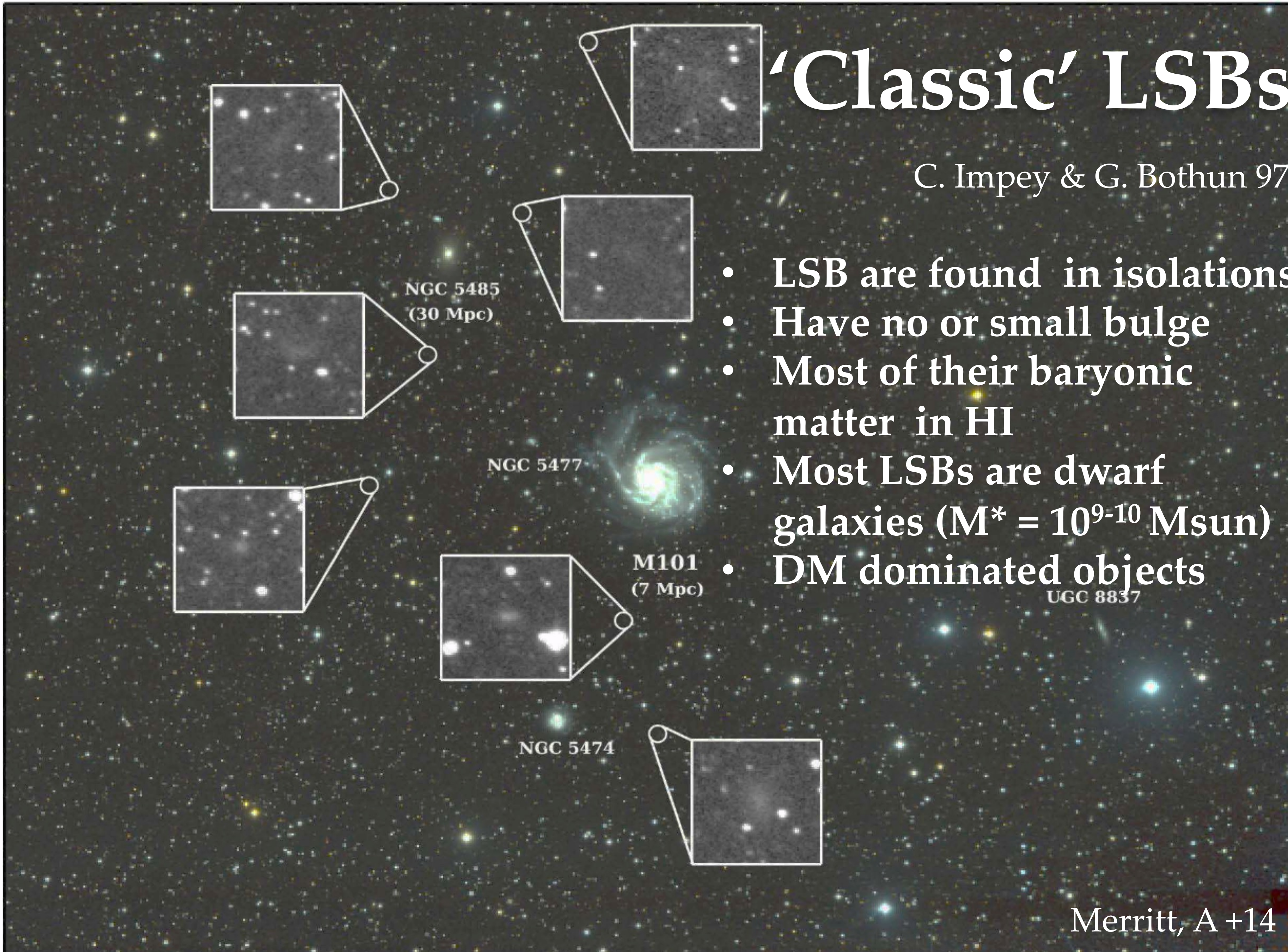
DIGESTIVO Project

DIffuse **G**alaxy **E**xpansion **S**igna**T**ures **I**n **V**arious **O**bservables project: understanding the emergence of diffuse, low surface brightness galaxies and the link to their dark matter haloes

‘Classic’ LSBs

C. Impey & G. Bothun 97

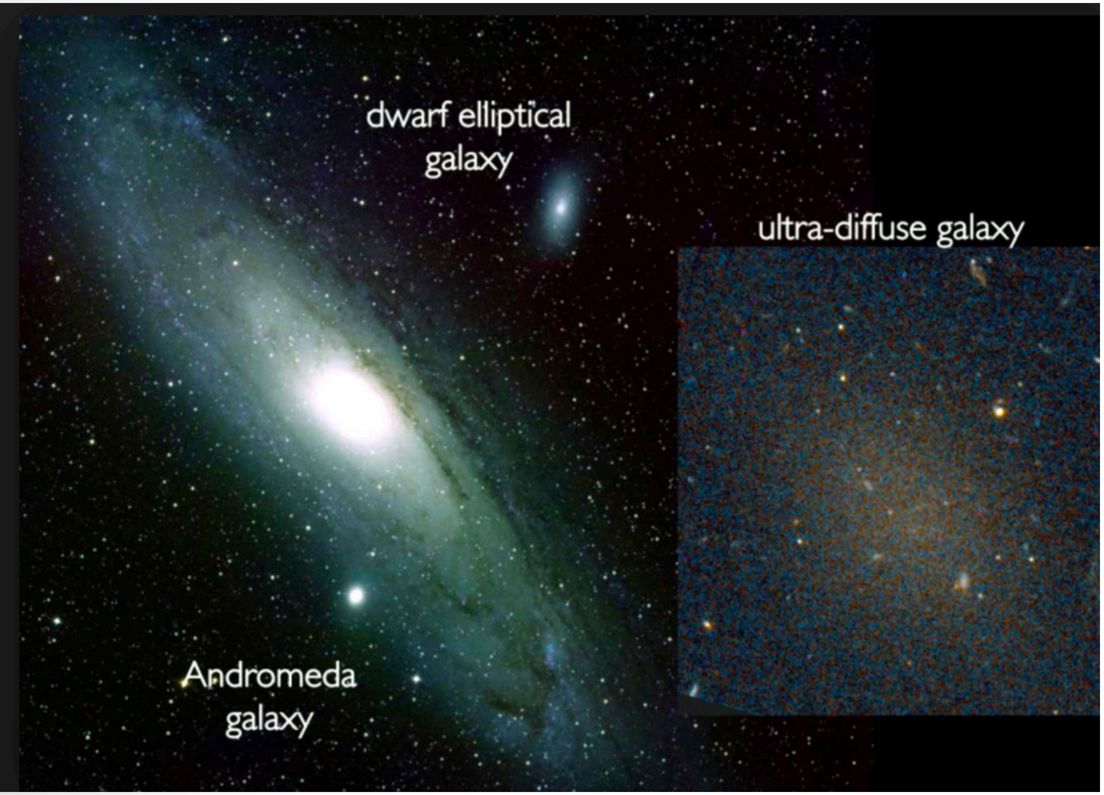
- LSB are found in isolations
- Have no or small bulge
- Most of their baryonic matter in HI
- Most LSBs are dwarf galaxies ($M^* = 10^{9\text{-}10}$ Msun)
- DM dominated objects

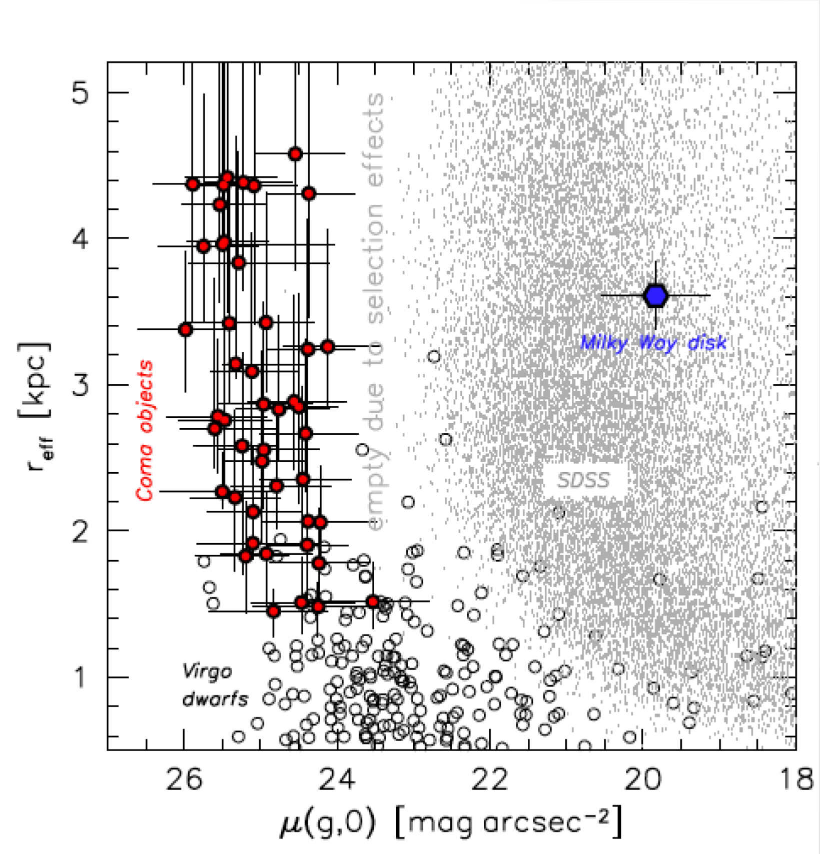


Merritt, A +14

~1000 UDGs in Coma cluster

Low surface brightness objects with LUMINOSITY of dwarfs **($M^* = 10^{7-9}$ Msun)** but SIZES of Milky Way-type spirals. **Are they formed outside of clusters?**





van Dokkum +15 using Dragonfly Telephoto Array
See also Koda +15 using SUBARU Suprime-Cam
Roman & Truijllo 16 using SDSS Stripe82, See also Mihos+15, Van der Burg+16

Can LCDM predict and explain the existence of such low surface brightness objects?

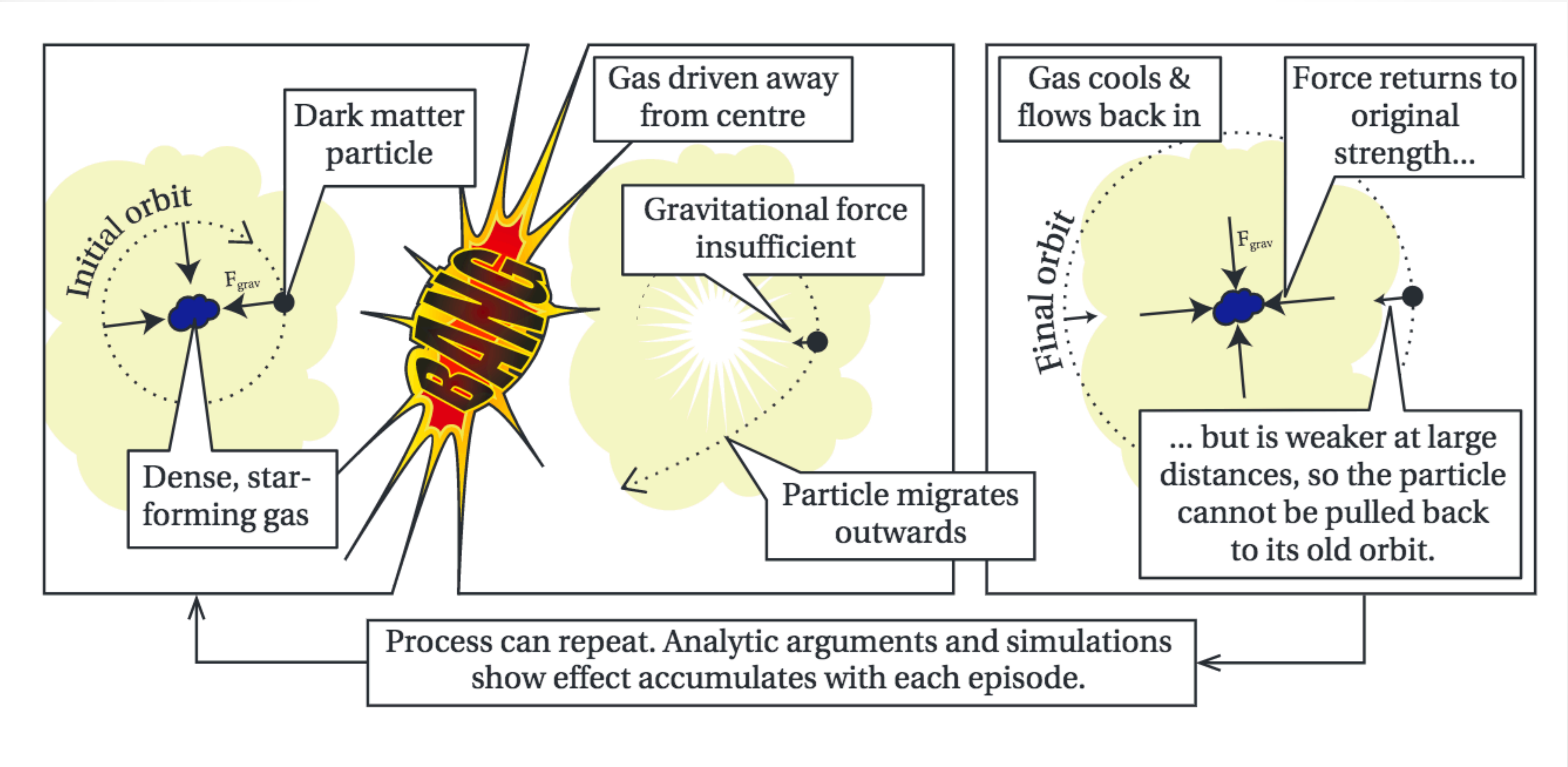
NIHAO 你好
Galaxy Simulations

PIs Maccio', Dutton

- Gasoline 2.0-blastwave feedback a la Stinson+06
- Planck Cosmology
- ***125 high resolution (zoomed) galaxies***
- more than $\mathbf{10^6}$ particles in each halo
- $10^5 - 10^{11}$ $M_\odot$ stellar mass range ($5x10^8 - 5x10^{12}$ $M_\odot$)
- 100 times better resolution than ILLUSTRIS
- 50 times better resolution than EAGLE volume
- 10 times more galaxies than FIRE (13 vs. 120)

From gas outflows to DM 'cores'

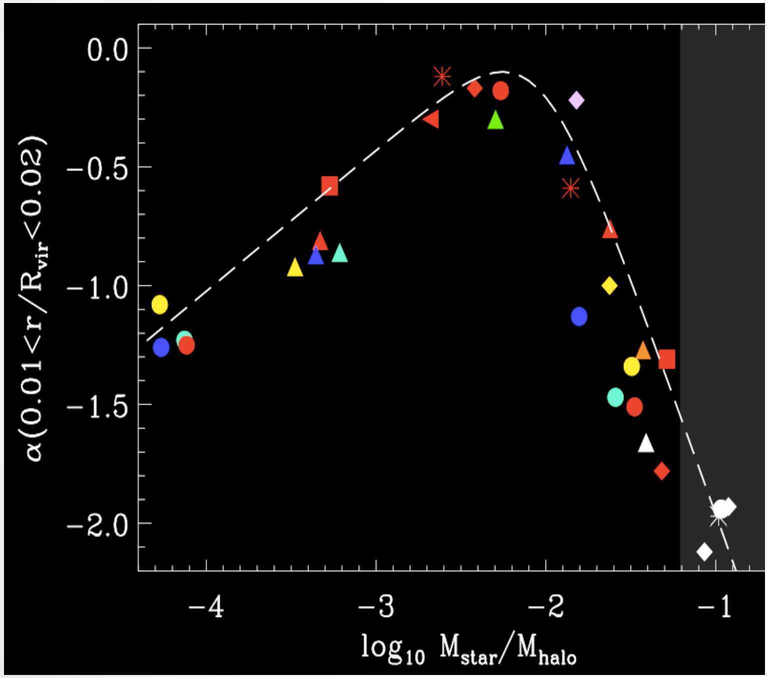
Core formation mechanism -> outflows driven by SNae feedback

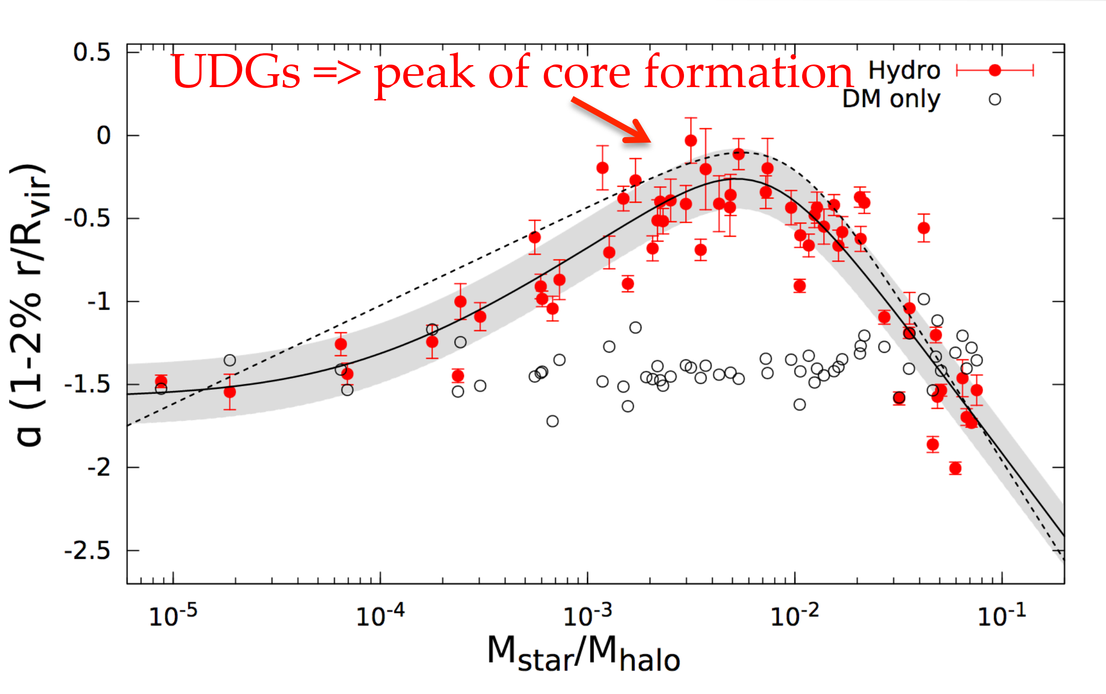


Pontzen & Governato 14

NIHAO galaxies form DM cores

Peak of core formation at log(M*/Mhalo)~-2.4 → M*~$10^{8.5}$ Msun (Di Cintio+14)
Core created during starburst events that launch powerful gas outflows

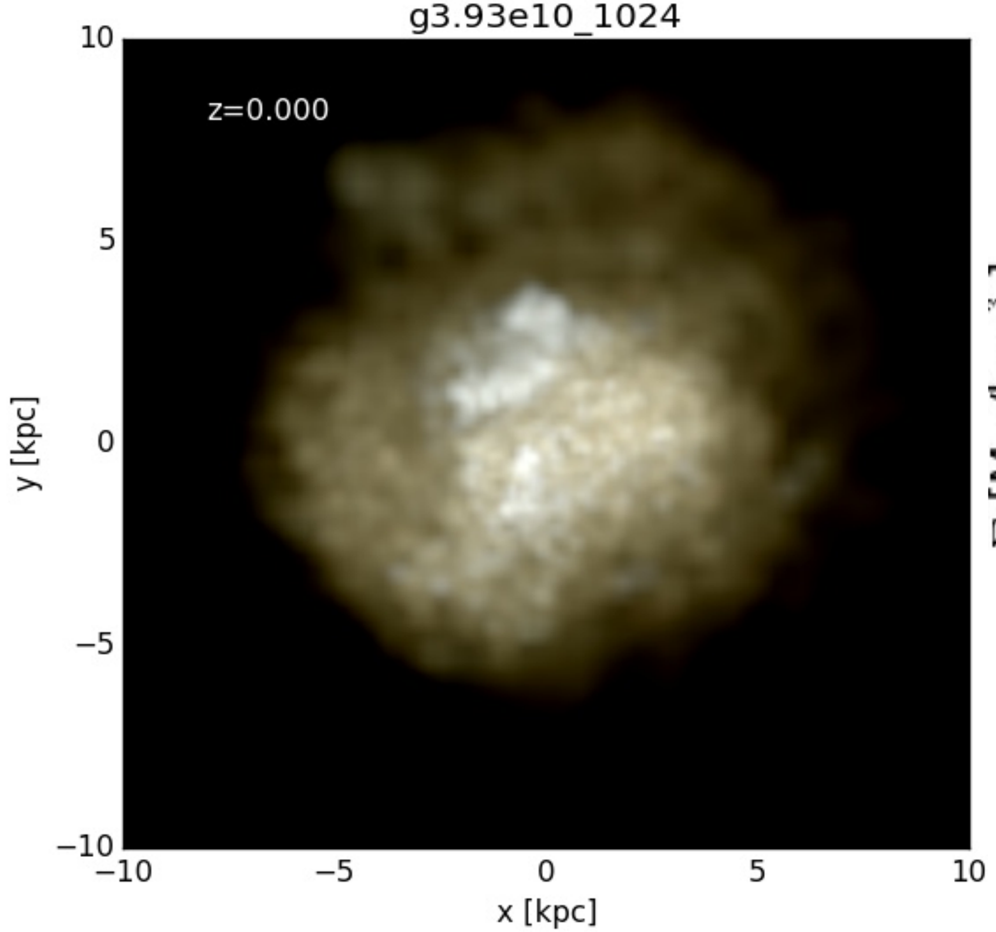




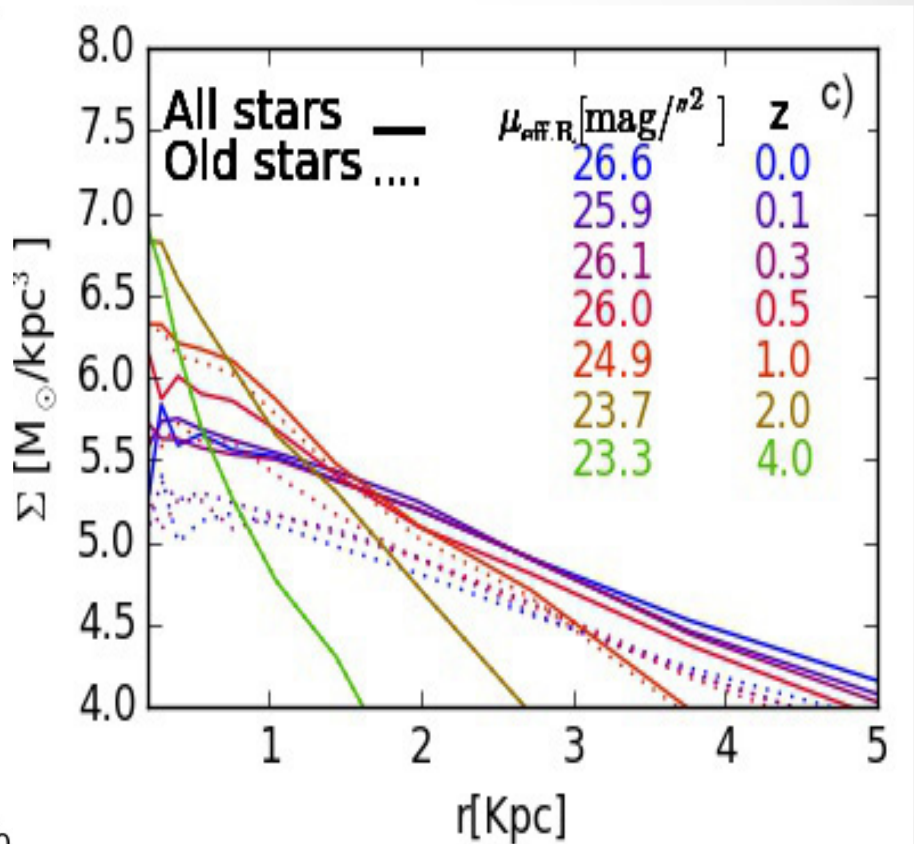
Di Cintio +14 a,b
Chan+15
Tollet+16

Dark matter profiles determined by two opposite effects: energy from Sne vs gravitational potential of the DM halo

Formation scenario of UDGs

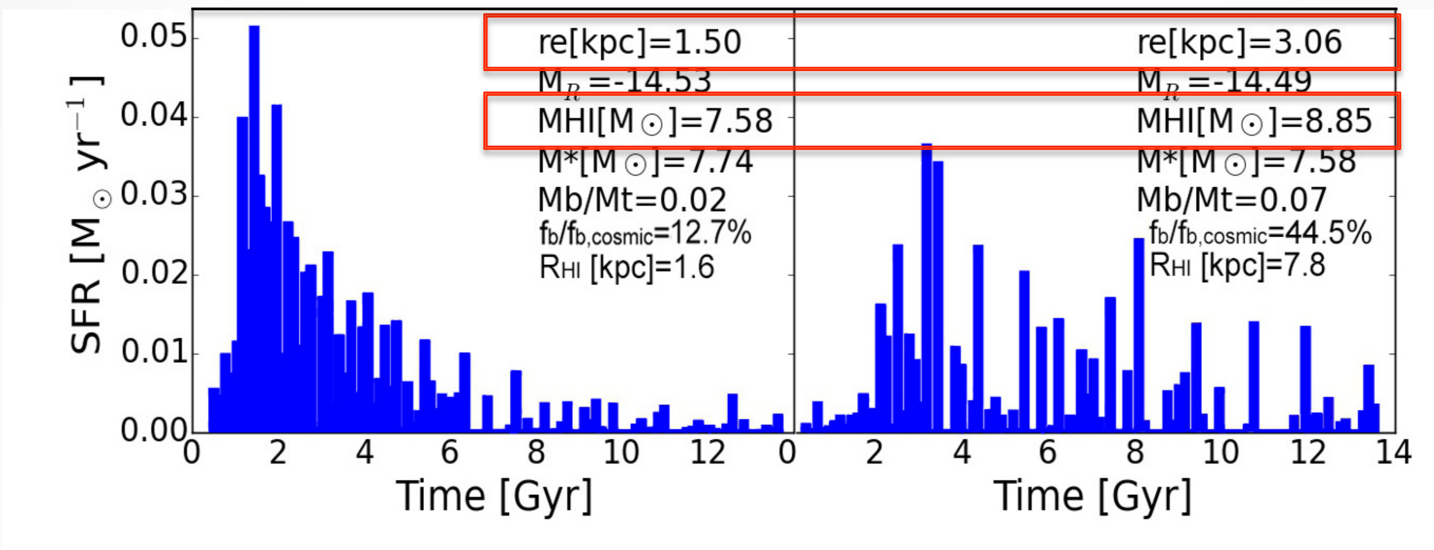


Stellar evolution



Di Cintio +17

SFH Observational Predictions



The largest isolated UDGs should contain more HI gas, have a larger baryon fraction and a more extended and *bursty* SFH than less extended dwarfs of similar M⋆

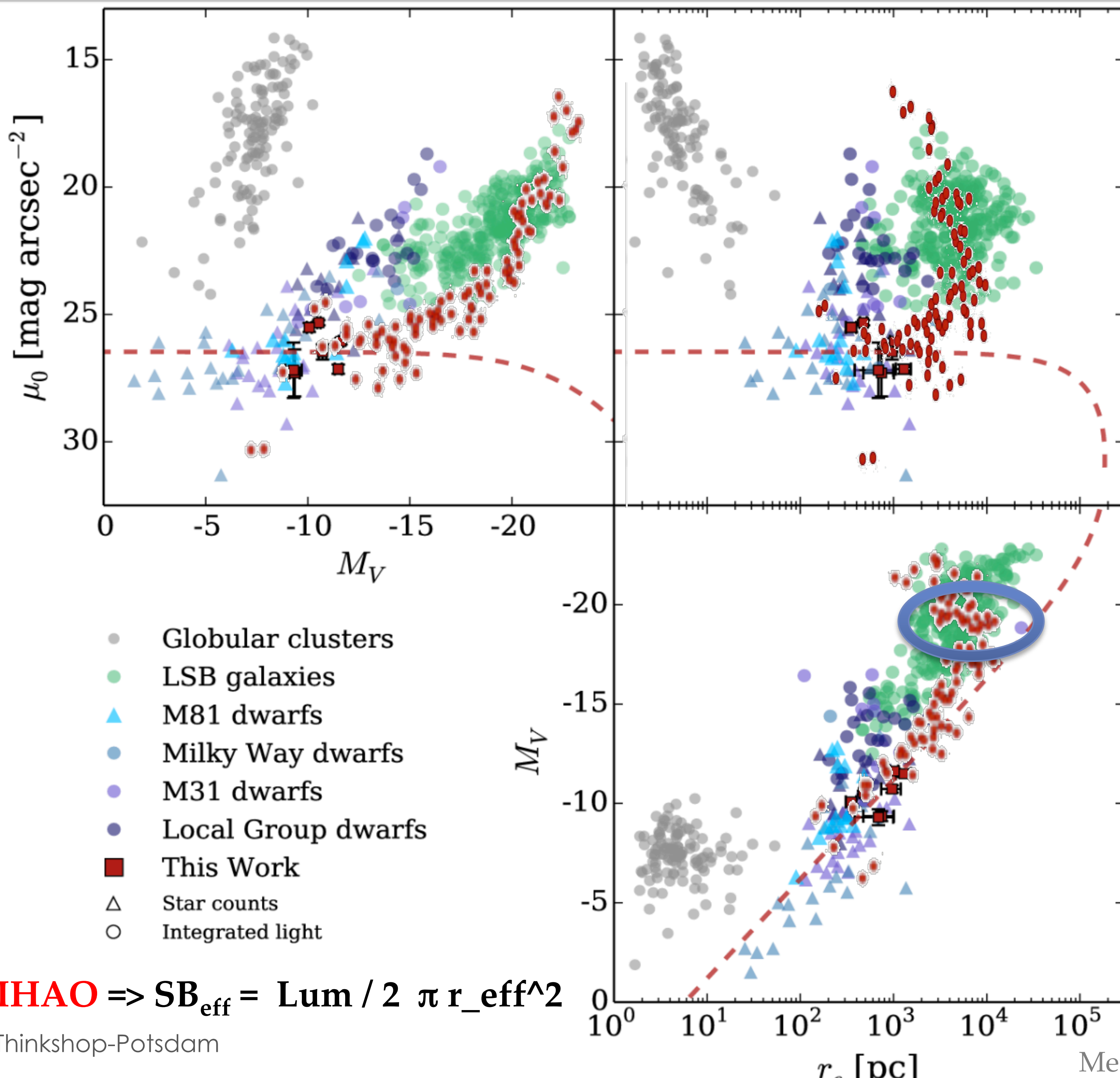
Di Cintio +17
(see also Onorbe+15, Read+16 for core size dependence on SFH in smaller haloes)

CDM+ baryonic physics Predictions for UDGs!

- Halo mass of dwarfs OBS VERIFIED!
- Found in isolation WORK IN PROGRESS
- Gas rich => the largest ones have higher gas fraction
- Bluer in field than in cluster
- Large gas extent
- ALFALFA dark galaxies can harbor UDGs
- Correlation between SFH and size
- Sersic index n~1
- Dark matter core!

Is the formation mechanism of LSBs the same as the UDGs´one?

- (Surprisingly ?) the formation scenario of large LSBs (Mstar~$10^{9.5-10}M_{sun}$) is **different** than the one of small UDGs (Mstar~$10^{7-9}M_{sun}$)
- And so are the observational predictions …



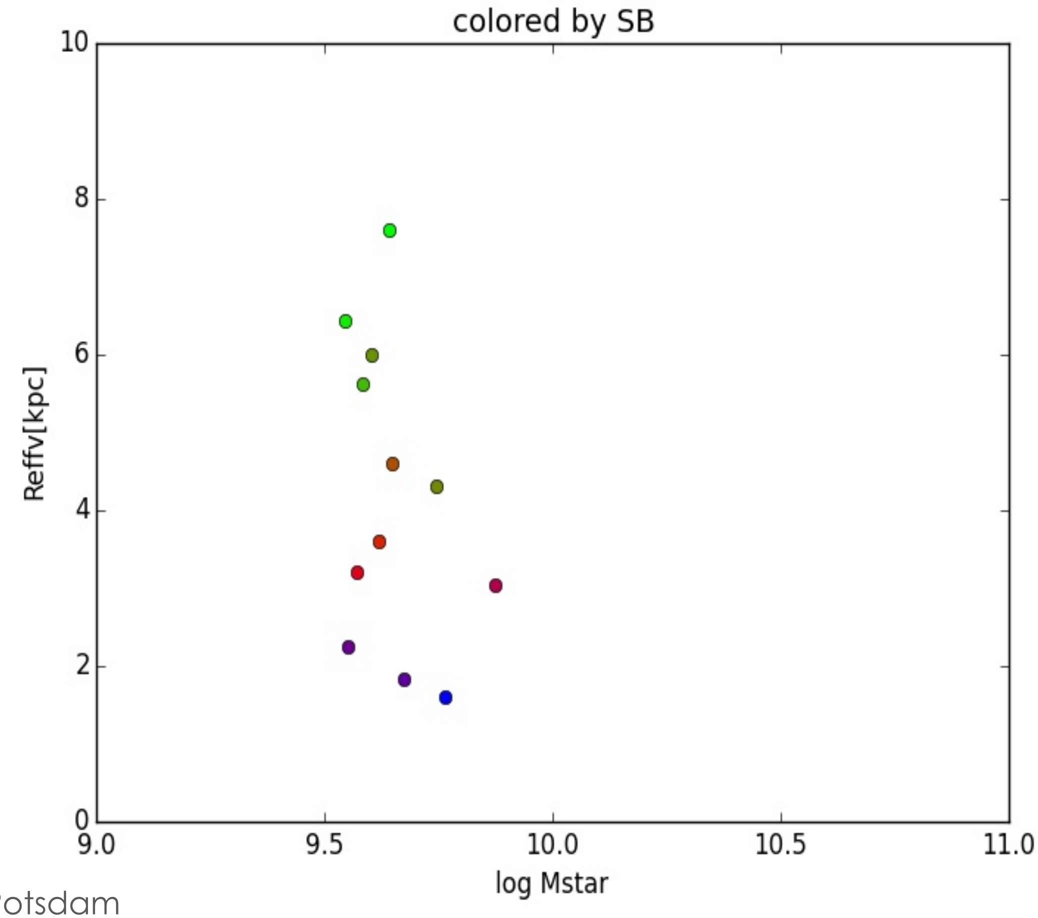
NIHAO => SB$_{eff}$ = Lum / 2 π r_eff^2

Merritt+14

Selection of LSB in NIHAO

9.8 < log(M*/Msun) < 9.5
Reff>1 kpc
20< Sbeffv/(mag/arcsec2)<25.0
Mhalo~2-5 x 10^11 Msun

What causes the large spread in size – or surface brightness- at a fixed stellar mass?



What makes LSBs?

Work in progress..check out the paper on arxiv soon!

Conclusions

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- UDGs formation mechanism is solely based on internal feedback driving gas outflows and generating DM and stellar "expansion". Obs signatures: largest gas fraction for largest Reff

- **For LOW SURFACE BRIGHTNESS OBJECTS, Mstar~$10^9$$M_{sun}$ represents the**

- Diversity of SBs in the ´classic´ LSBs regime is a reflection of the variety of