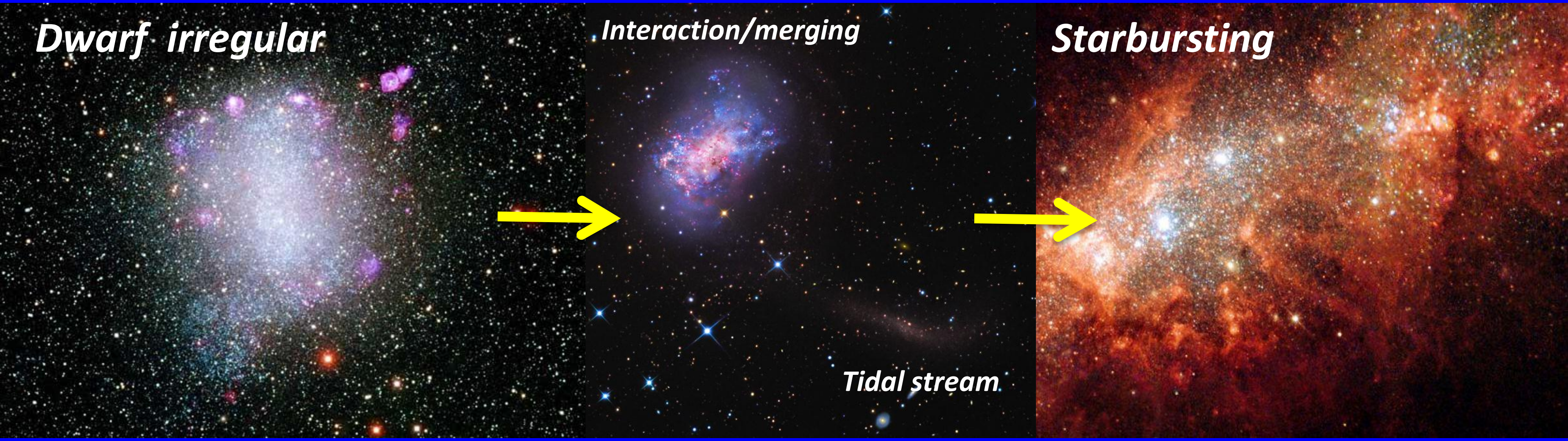
Formation of BCDs from interacting/merging dwarf irregular galaxies.

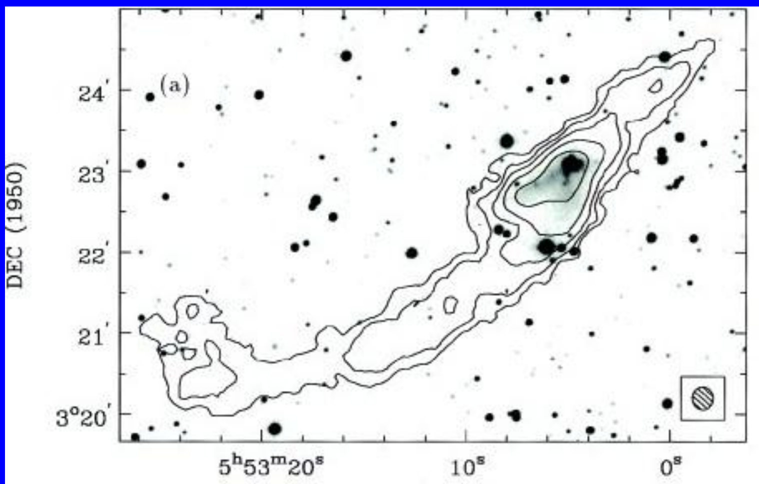


NGC 6822 *NGC 4449* *NGC 1569* [From APOD]

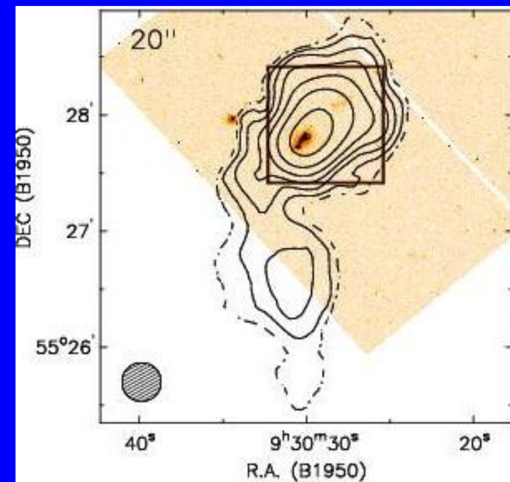
Kenji Bekki (ICRAR at UWA, Australia)

Interacting/merging dwarfs →BCDs ?

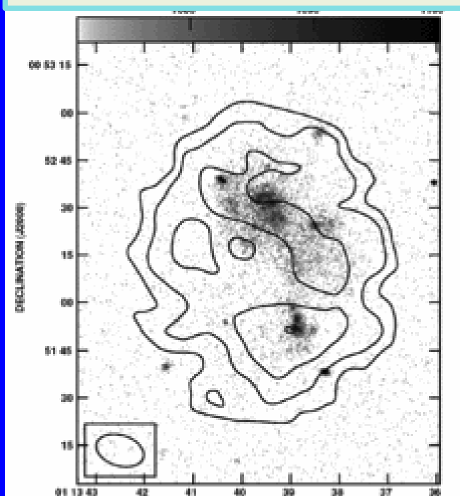
Opitcal+HI images of BCDs



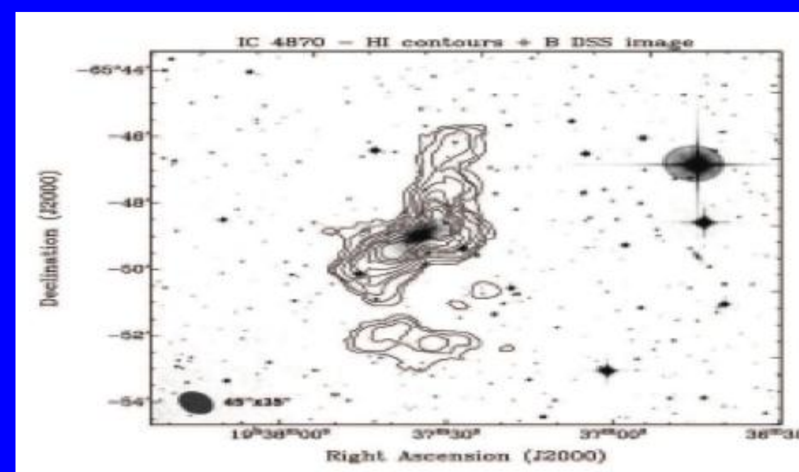
II Zw40 (van Zee et al. 1998)



I Zw 18 (Lelli et al. 2012)



UGC 772 (Ekta et al. 2008)



IC4870 (Lopez-Sanchez et al. 2010)

Possible observational evidence for BCD formation from interacting/merging dwarfs.

- Evidence for disturbed morphologies in HI gas and stellar components (e.g., Ekta et al 2008)
- About 80% of BCDs were formed from merging or interacting dwarfs (Pustilnik et al. 2001: 67% in Sung et al. 2002; but see Sell 2012, AAS for a minor fraction of merger BCDs).

From old to new models.

Mon. Not. R. Astron. Soc. **388,** L10–L14 (2008)

doi:10.1111/j.1745-3933.2008.00489.x

Formation of blue compact dwarf galaxies from merging and interacting gas-rich dwarfs

Kenji Bekki

School of Physics, University of New South Wales, Sydney 2052, NSW, Australia

Accepted 2008 April 25. Received 2008 April 23; in original form 2008 March 26

ABSTRACT

We present the results of numerical simulations which show the formation of blue compact dwarf (BCD) galaxies from merging between very gas-rich dwarfs with extended H I gas discs. We show that dwarf–dwarf merging can trigger central starbursts and form massive compact cores dominated by young stellar populations. We also show that the pre-existing old stellar components in merger precursor dwarfs can become diffuse low surface brightness components after merging. The compact cores dominated by younger stellar populations and embeddedinmorediffuselydistributedolderonescanbemorphologicallyclassifiedasBCDs. Since new stars can be formed from gas transferred from the outer part of the extended gas discs of merger precursors, new stars can be very metal-poor ([Fe/H] < −1). Owing to very high gaseous pressure exceeding 10^5 k_B (where k_B is the Boltzmann constant) during merging, compact star clusters can be formed in forming BCDs. The BCDs formed from merging can still have extended H I gas discs surrounding their blue compact cores. We discuss whether tidal interaction of gas-rich dwarfs without merging can also form BCDs.

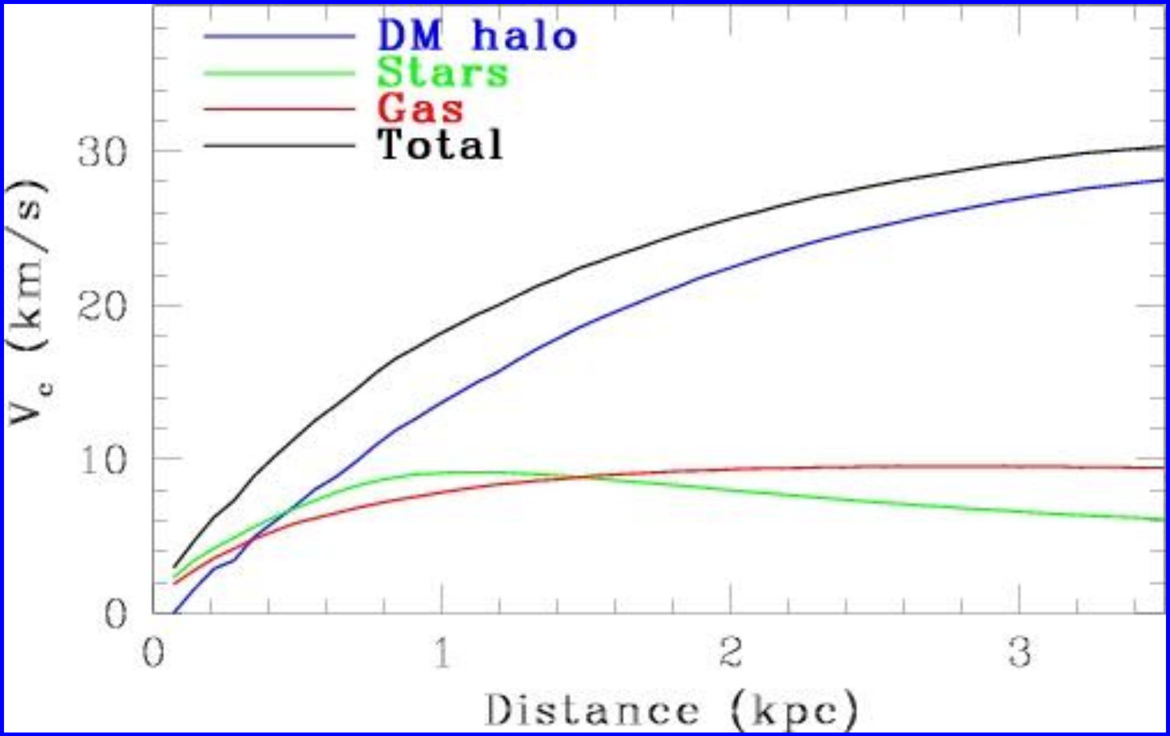
Key words: galaxies: dwarf – galaxies: kinematics and dynamics – galaxies: star clusters – galaxies: structure.

Bekki (2008)

The new chemo-dynamical model.

- GRAPE-DR/GPU-SPH chemo-dynamical simulations (~ 90 models, N=0.6-1.2*10^6)
- Chemical evolution: Prompt SN Ia + SN II & low-mass AGB stars (metallicity-dependent radiative cooling: Mapping III).
- Star formation: Jeans-instability criterion +Schmidt-law.
- Initial dIs: Slowly rising rotation curve (i.e., cored dark matter halo).
- Stellar masses of dIs: 10^7-$3*10^8$ M_{sun} .

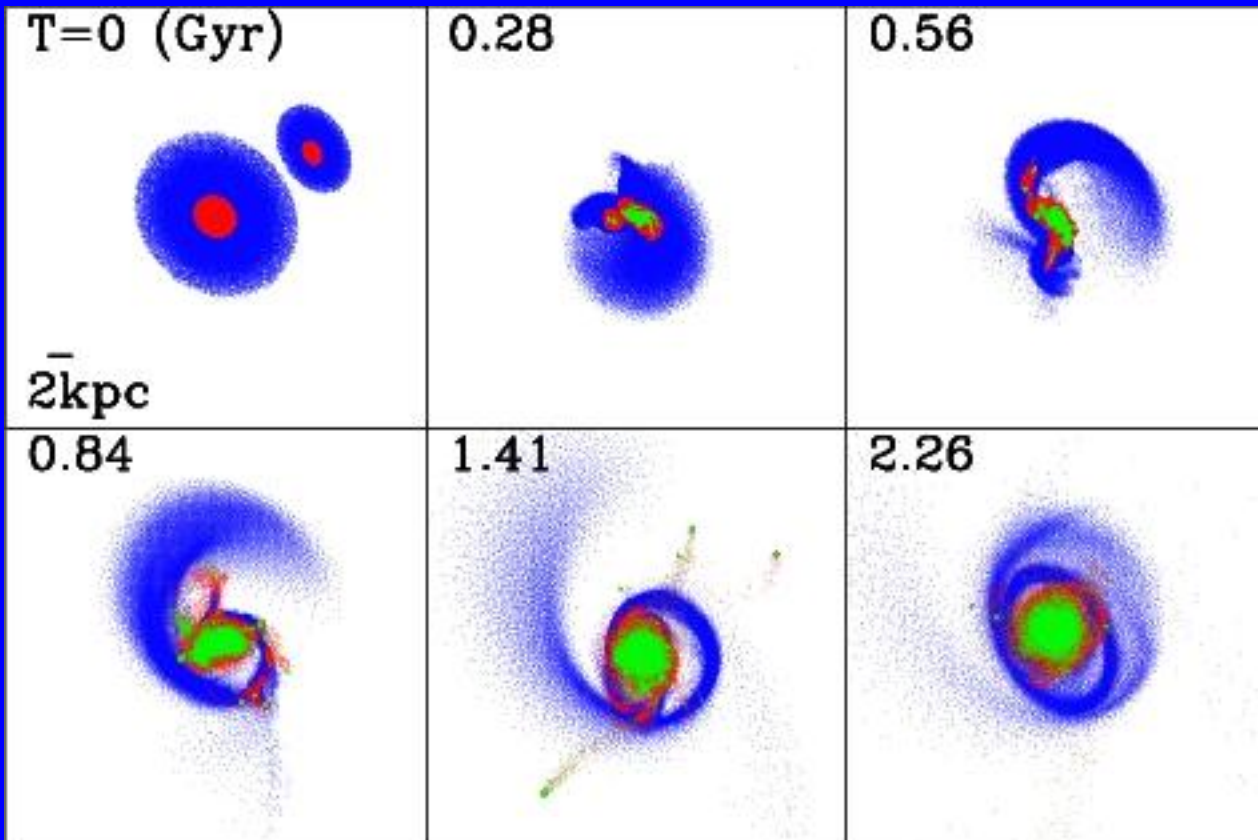
LSB dIs with cored DM halos.



$V_{c,max}$~30 km/s

- Adoption of the Burkert (1995) cored DM model.
- Slowly rising rotation curve profiles (V_c).

The model for dwarf interaction/merging.



Old stars

New stars

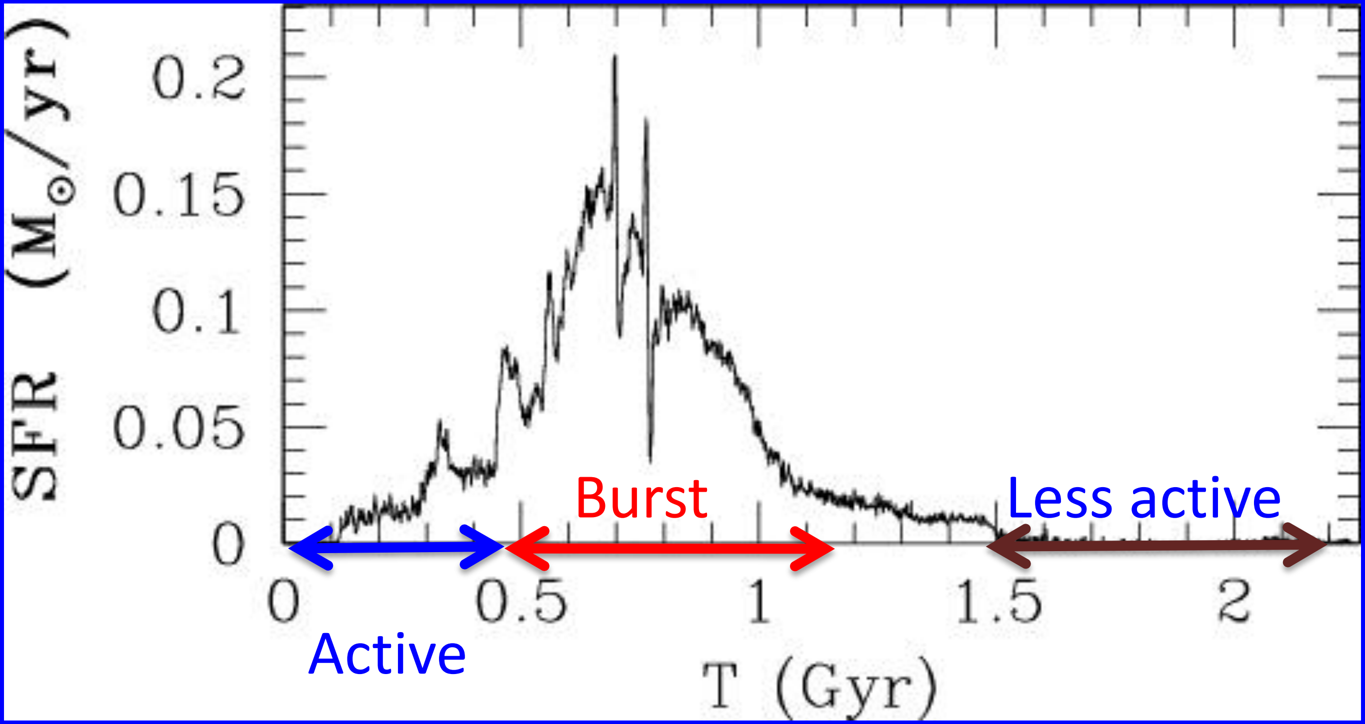
Gas

Merger:
m_2=0.3,
$f_g=M_g/M_s$=0.5,
$s_g=R_g/R_s$=4

- Extended gas disk R_g/R_s ~ 4-7 (e.g., Hunter 1997)
- High HI- mass-to-light ratios up to 20 M_{sun}/L_{sun} (e.g., Warren et al. 2004).

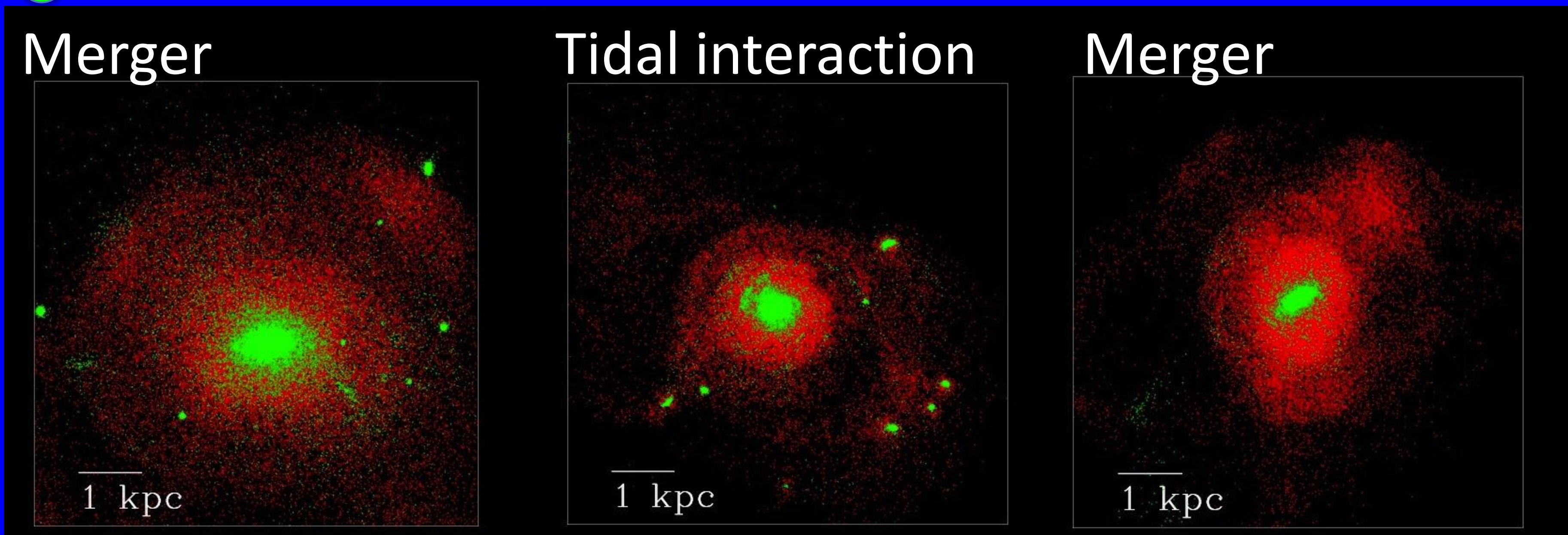
Selection of ``BCD phases'' from simulated dwarf mergers.

- Strong starburst epochs = BCD phases



Result 1: BCD morphology/Structure

Old stars
New stars

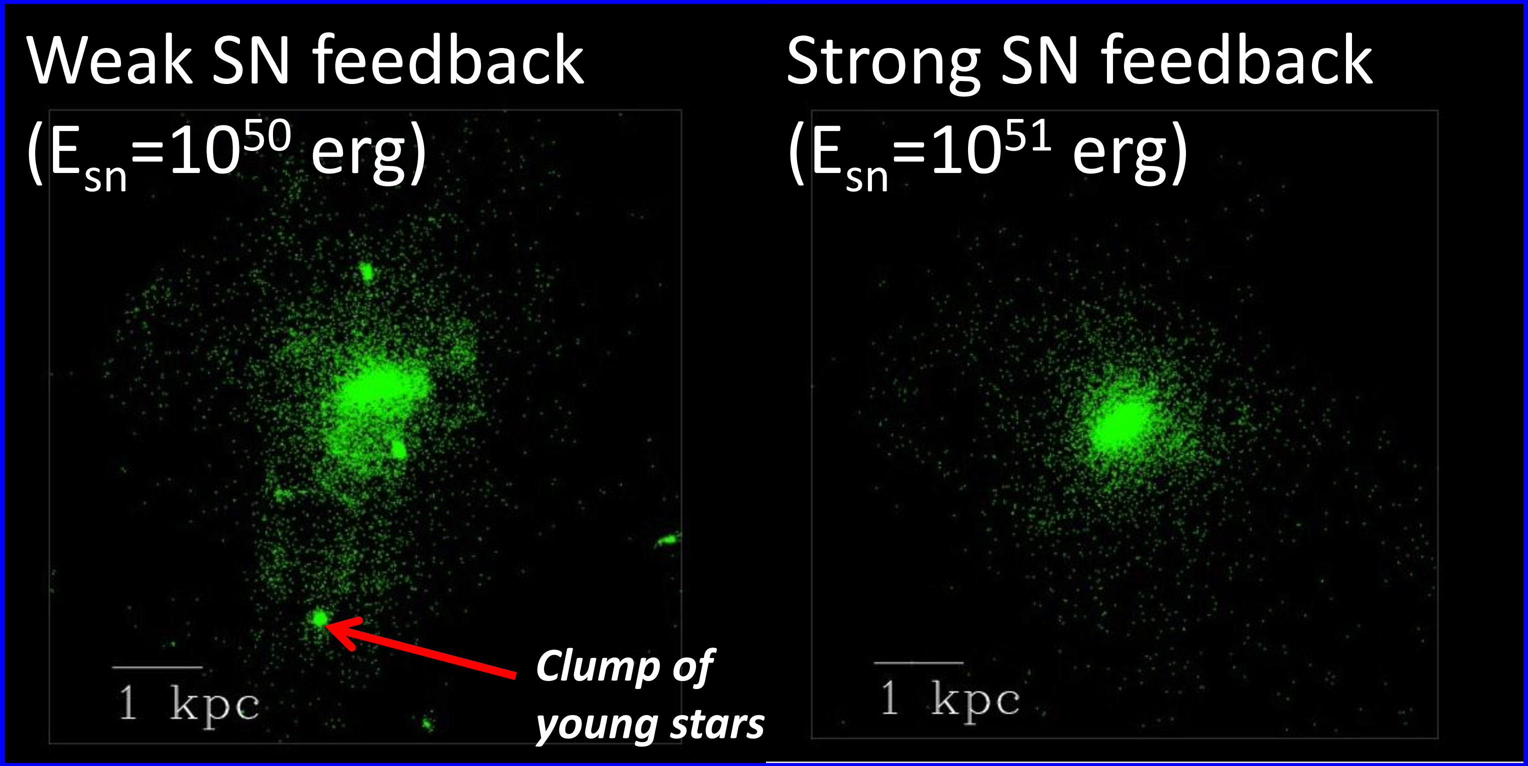


M_2=0.5,f_g=1.0; compact central starburst + clumpy star formation regions

M_2=1.0, hyperbolic; compact central starburst + clumpy star formation regions

M_2=0.5,f_g=0.3; compact central starburst only

Result 1: BCD morphology

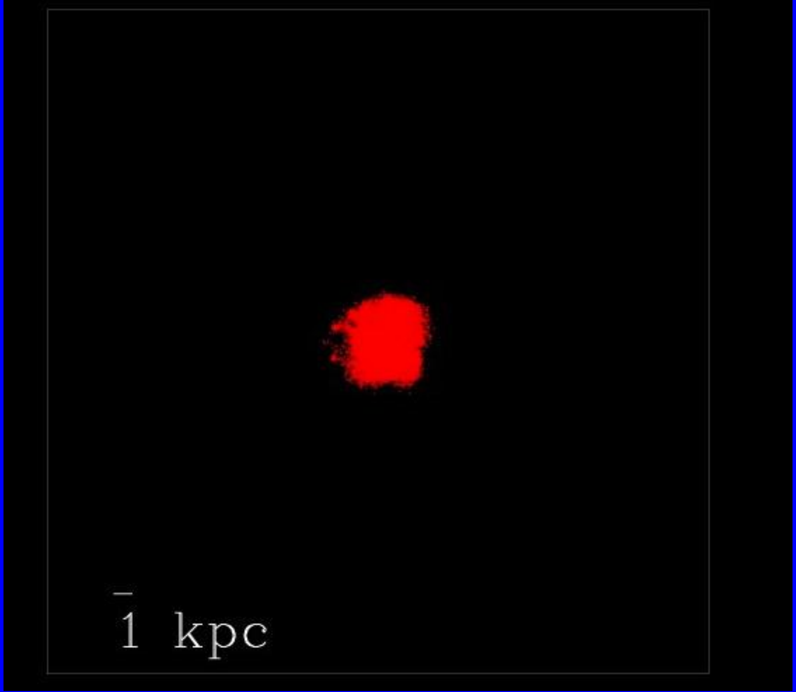


- Formation of stellar clumps (=GC progenitors ??) can be suppressed by SN feedback effects.

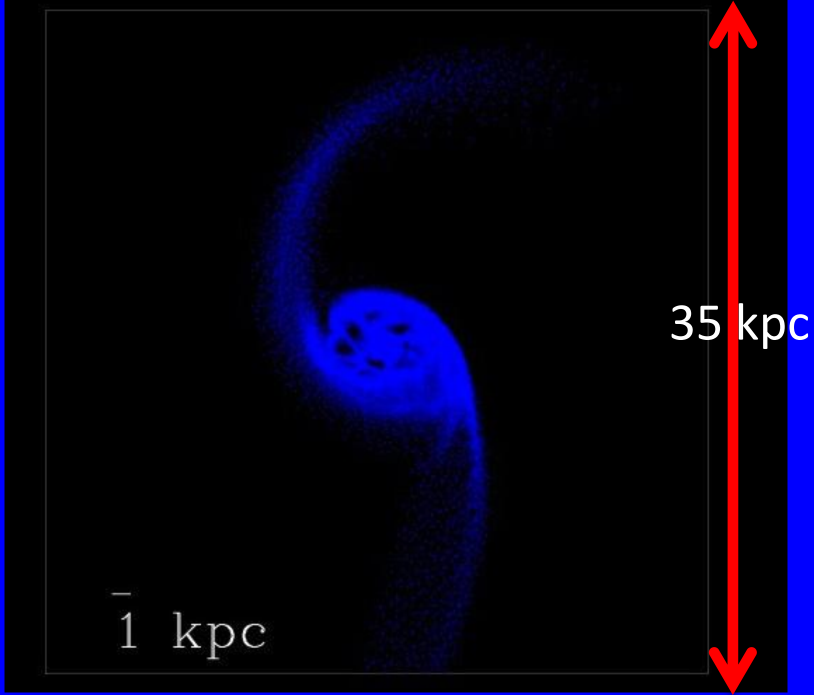
Result 1: BCD morphologies.

Hyperbolic tidal encounter of equal-mass dwarfs

Stars (less disturbed)

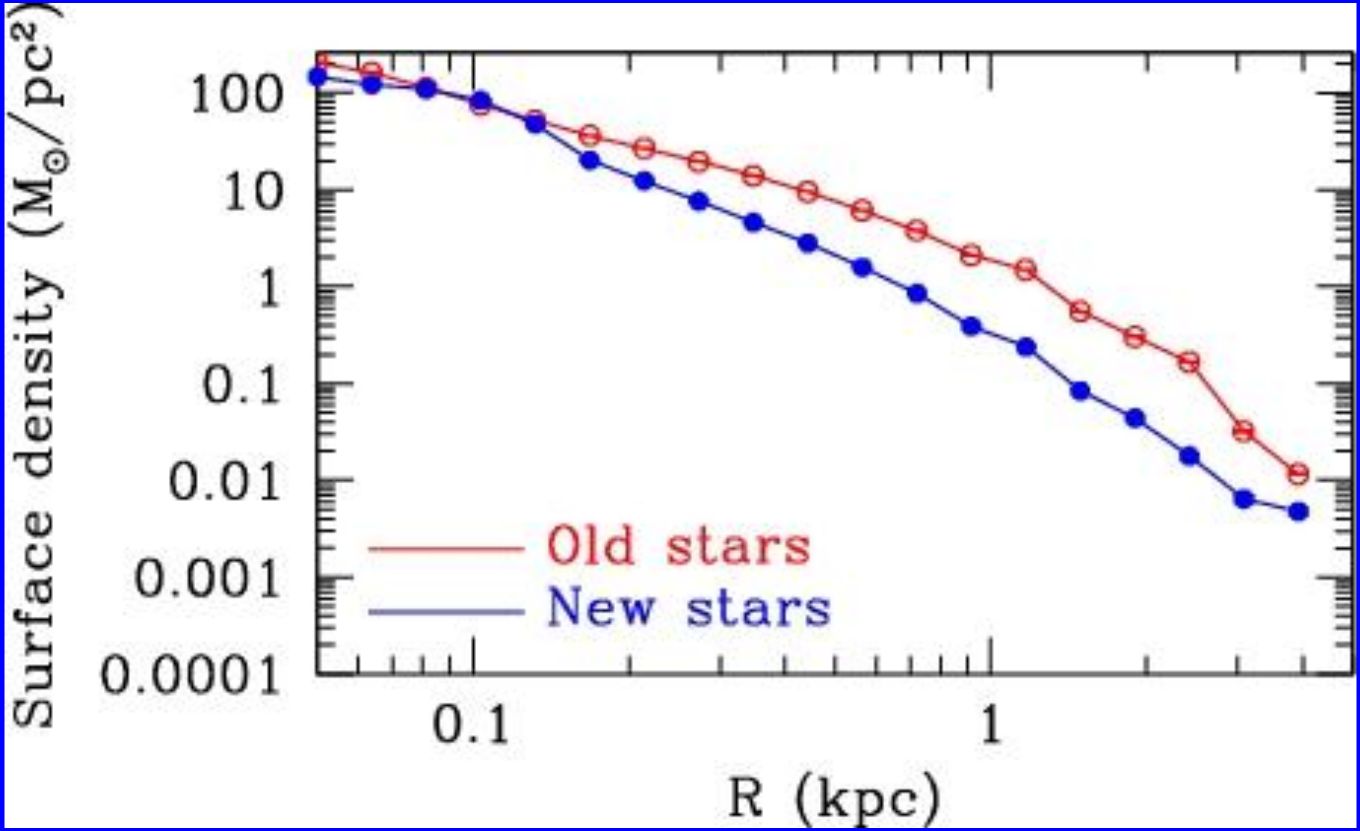


Gas (Strongly disturbed)



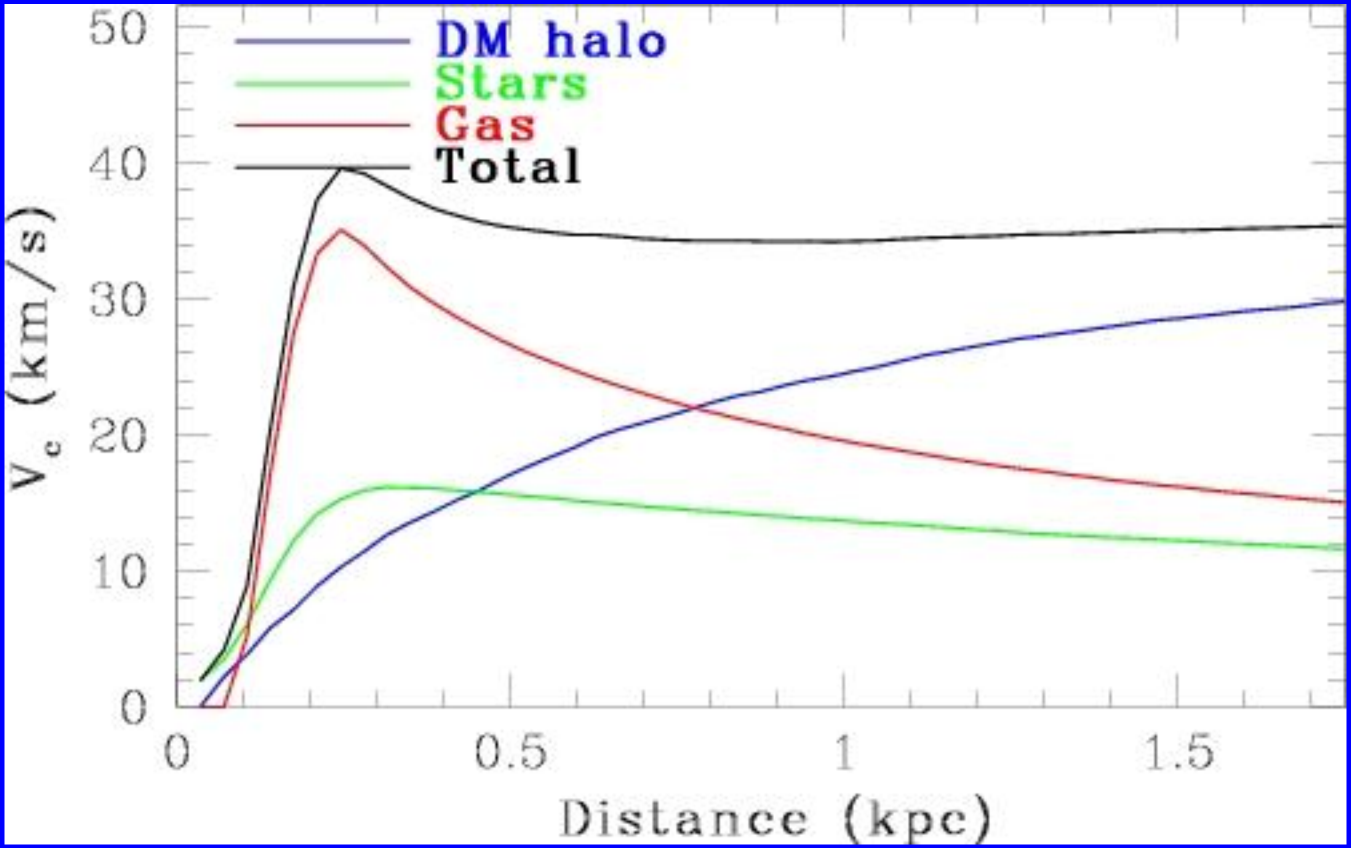
- Even apparently isolated BCDs in optical observations could be the remnants of past interacting dwarfs.

Result 1: Morphology/Structure



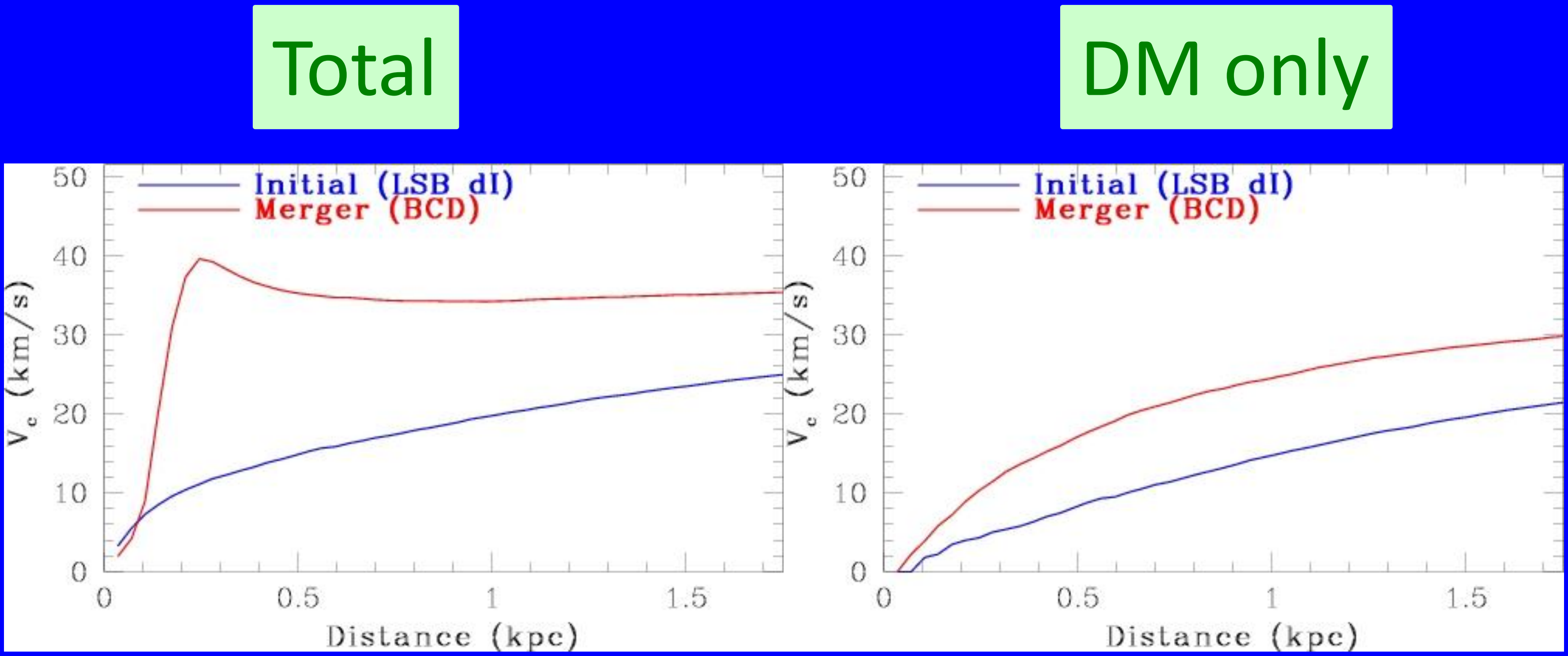
- The central region can be dominated by stellar light from new stars (owing to very low M/L). The simulated BCD has the outer diffuse old halo.

Result 2: Rotation curve profiles



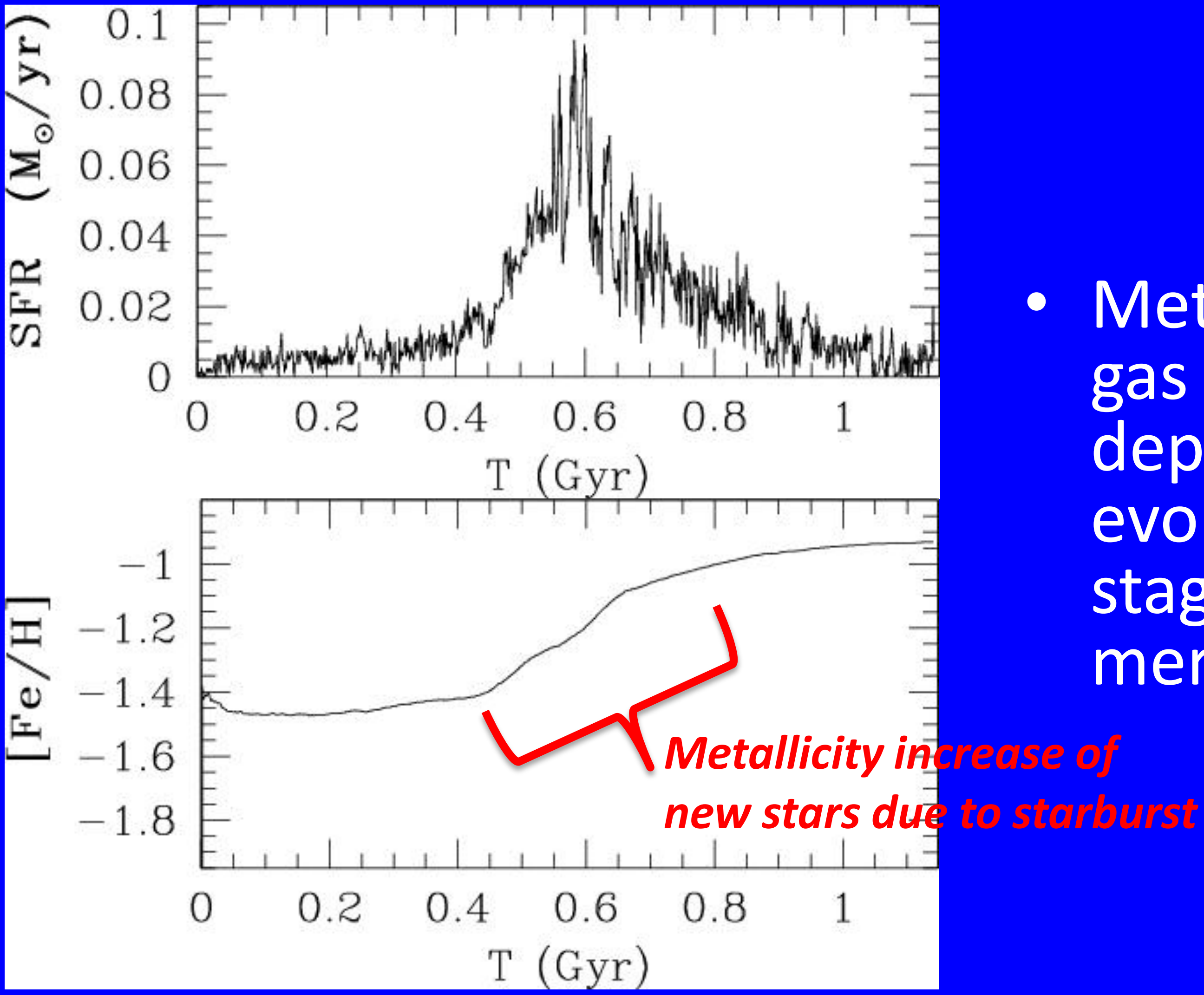
- BCDs formed from merging show steeply rising rotation curves due to mass concentration of new stars/gas.
- The differences of rotation curves between dIs and BCDs were previous discussed by Meurer et al. (1998) and van Zee et al. (2001).

Result 2: Rotation curve profiles



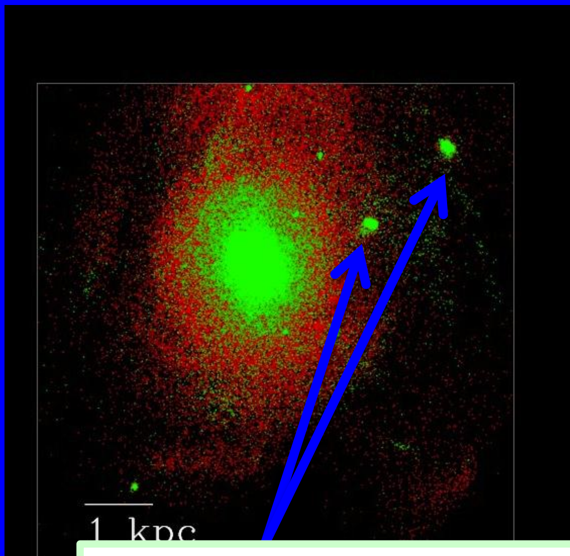
- During dI → BCD transformation, the rotation curve profiles can also change.
- Central DM densities can also increase due to mass increase of DM + DM contraction.

Result 3: Chemical evolution.



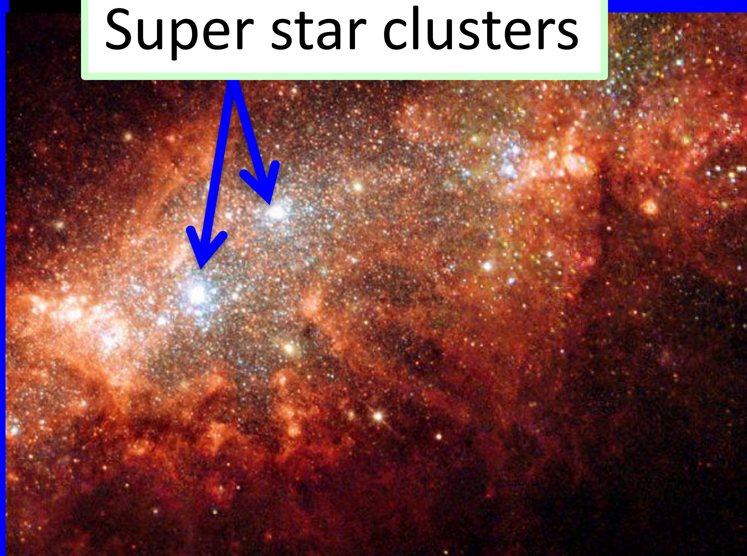
- Metallicities of gas and new stars depend on the evolutionary stage of dwarf merging.

Result 4: Formation of super star clusters ?



Simulation

Super star clusters

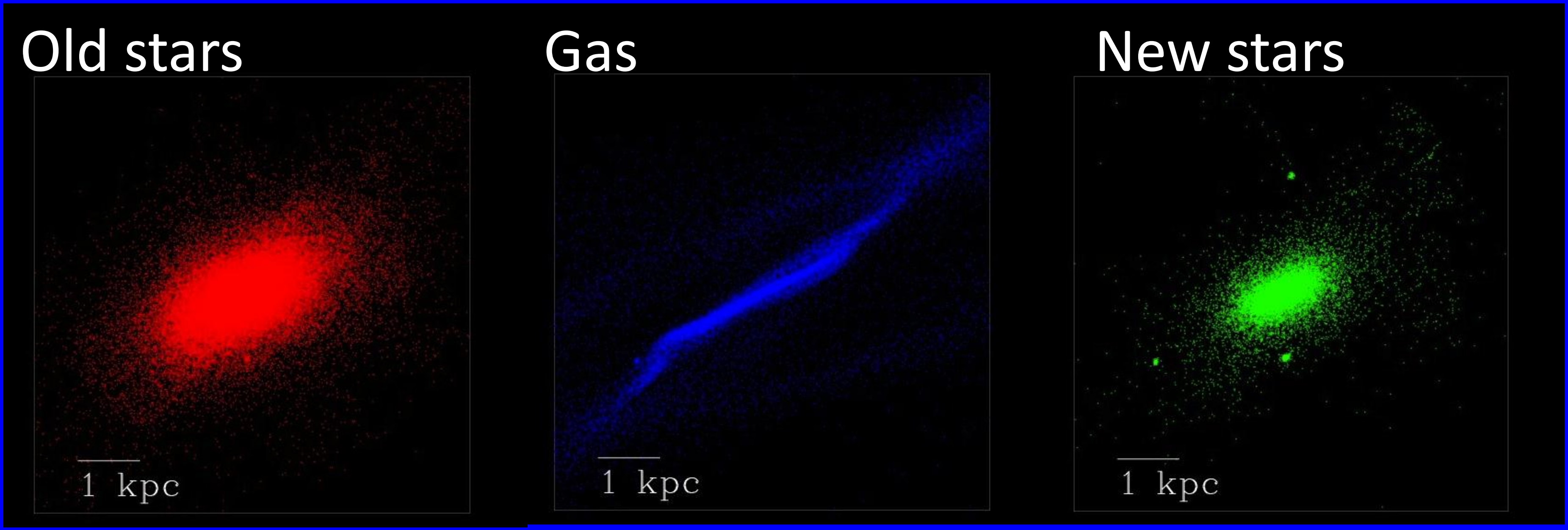


Observation
(NGC 1569: APOD)

Evolution to GCs ?

Result 5:   Descendants of BCDs.

Mass distribution ~ 1 Gyr after BCD phases:

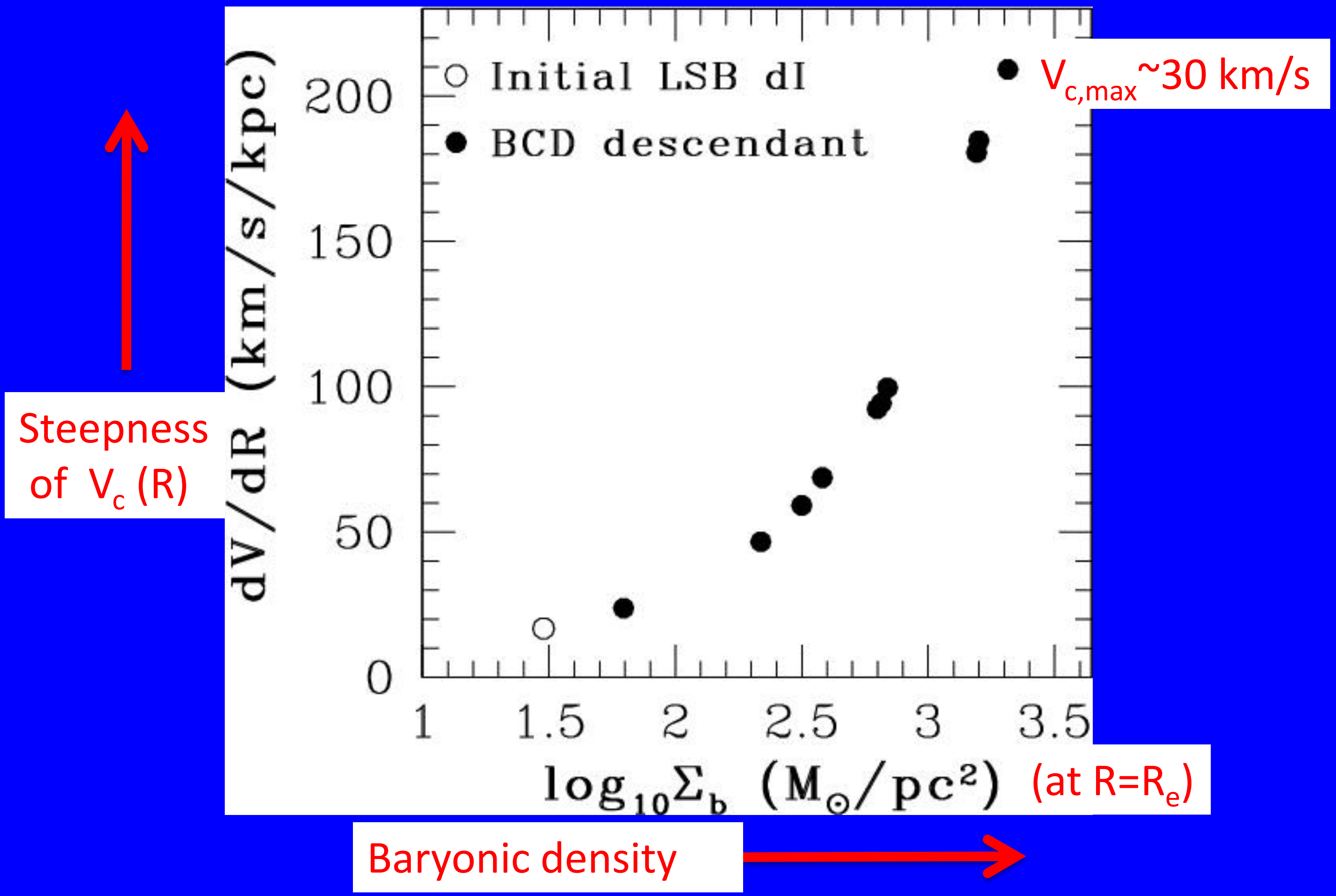


Diffuse halo,
Dynamically hotter
(but still rotating)

Extended, rotating,
lower density, outer
warps (weak SF).

More compact,
more rotation,
young GCs (?)

Result 5: Descendants of BCDs.



Conclusions

- Transformation: LSB and gas-rich dIs → BCDs → HSB dwarfs.
- BCD descendants = HSB dwarfs with dynamically hotter old spheroid + gas disk + younger stars with disky spatial distribution.
- Rotation curve changes: from slowly to steeply rising rotation curves owing to mass-transfer during merging/interaction.
- Formation of very compact star-forming regions, which could be progenitors for GCs.