GALAXY EVOLUTION AT COSMIC DOWN: COMPARING SIMULATED GALAXIES AT $z \sim 6, 4$ & 2

Da Bi[1], Isaac Shlosman[1,2], Emilio Romano-Díaz[3]

1.Department of Physics & Astronomy, University of Kentucky, Lexington, KY, USA 2. Theoretical Astrophysics, Graduate School of Science, Osaka University, Osaka, Japan 3.Argelander-Institute for Astronomy, Bonn, Germany

Introduction:

- The two prevailing morphological types of galaxies-disks and ellipticals, comprise the Hubble Tuning Fork of galaxies in the contemporary universe.
- The current paradigm states that environment plays a decisive role in shaping galactic morphologies.
- Do parent dark matter (DM) halo properties, spin and mass comprise additional factors determining galactic morphologies ?
- Our simulations are aimed at analyzing emerging galactic morphology subject to these additional factors.

Method:

We use zoom-in cosmological simulations to follow the evolution of galaxies constrained to form in DM halos of the roughly same mass, at z = 6, 4 & 2. For each halo (same spin λ, and environment δ) two different versions of galactic wind have been run with. We pay particular attention to the influence of different feedback mechanisms (galactic winds) on the morphological properties of the central galaxies, as well as their gas content.

Halo No.	z[target]	z[reached]	Halo Mass [log(M/h)]	Halo Spin λ	Galactic Winds Feedback
5	6	6	11.5	0.03	CW
	6	6			VW
4	6	6	11.5	0.02	CW
	6	6			VW
15	4	4	11.6	0.06	CW
	4	4			VW
12	4	5.4	11.6	0.02	CW
	4	4.6			VW
18	2	4.1	11.7	0.02	CW
	2	3.6			VW
20	2	2	11.7	0.03	CW
	2	2			VW

Table 1. Simulation suite with different galactic wind feedbacks, constant wind (CW) and variable wind (VW). Ongoing simulations are colored in red.

We use our modified version of the hybrid N-body/hydro code GIZMO (Hopkins 2017)[1] with the meshless finite mass (MFM) hydrosolver and an adaptive gravitational softening for the gas. We adopt the Springel & Hernquist (2003)[2] multiphase algorithm, which includes the feedback from SN Type II. Two different algorithms of the galactic wind are being used: the Constant Wind (Springel & Hernquist 2003)[2] and the Variable Wind (Choi & Nagamine 2010)[3].

In order to determine their observational properties (as would be dectected by JWST), we have post-processed our galaxies with the radiative code SKIRT[4].

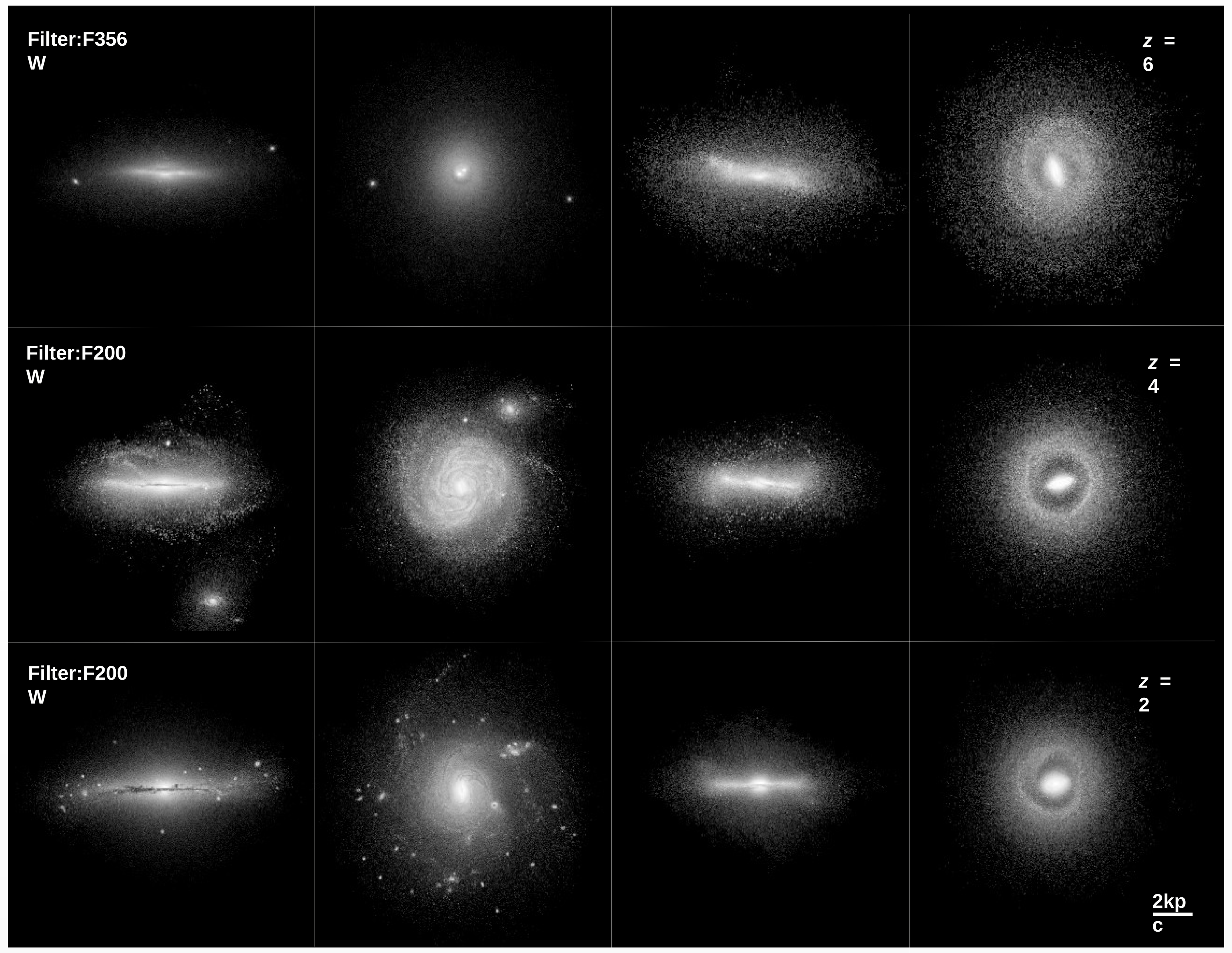


Fig 1 Idealized synthetic images of modeled galaxies in the JWST broadband filters. Each galaxy is showed in face-on and edge-on projections. Note the presence of rich stellar clump population in CW and more pronounced bars and rings in VW.

Results:

Our (preliminary) results only include the finished runs.

We have analyzed our JWST-like images in order to determine their morphologies. Fig 2 shows the results of 2D Sersic profiles fitting, while Fig 3 the bulge+disk decomposition in 1D. The general morphology classification defined by the Gini-M20[5] diagram is shown in Fig 4.

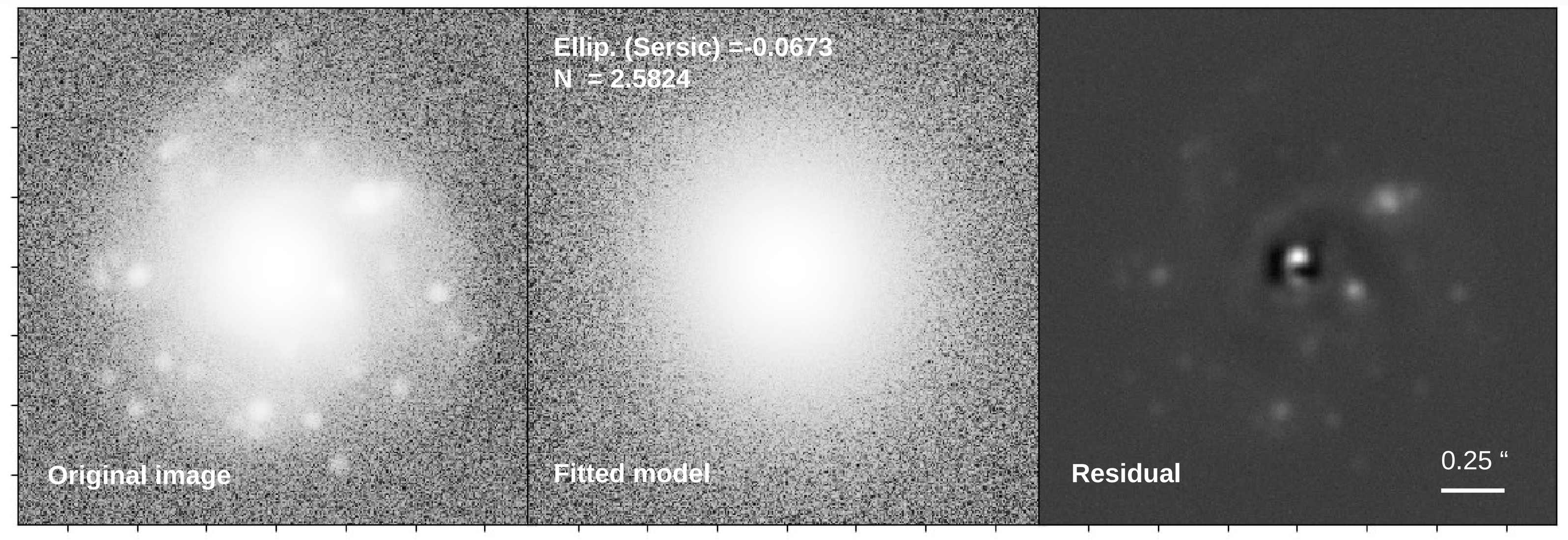


Fig 2. 2D Sersic profile fitting[6] for galaxy No,20 at z=2 with CW

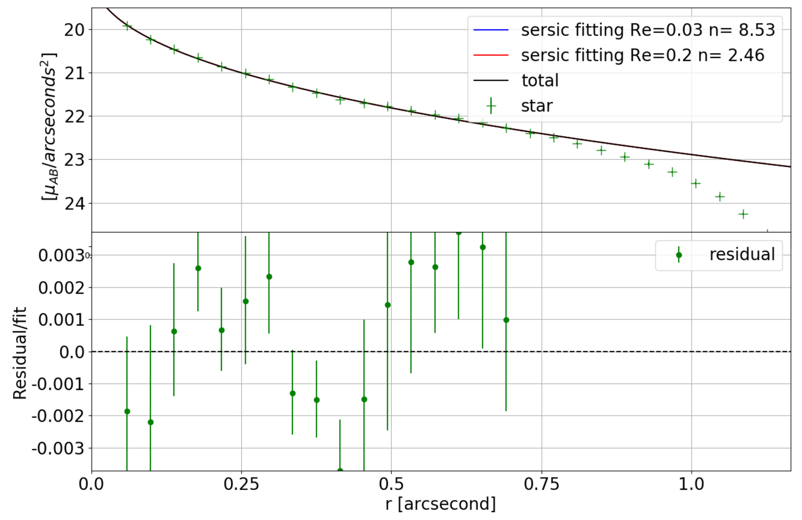


Fig 3. 1D 2-component decomposition for galaxy No.20. Only one Sersic profile (n = 2.5) is needed (bulgeless galaxy), as shown in the upcoming paper (Da et al).

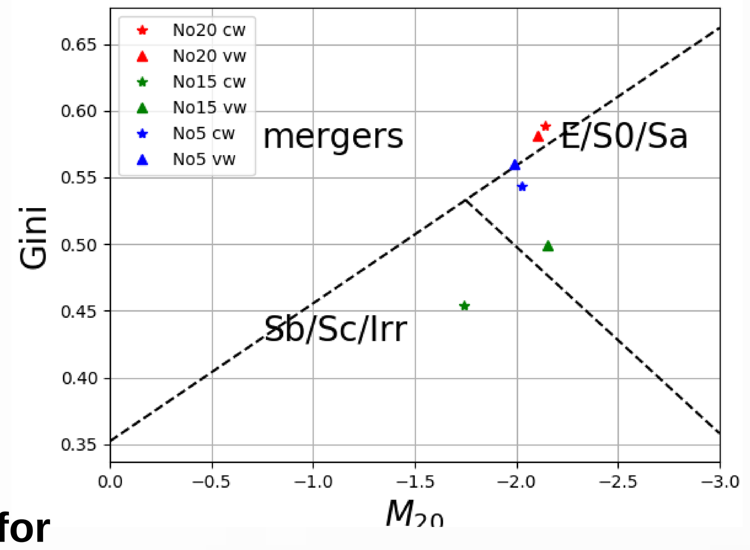


Fig 4. Gini-M20 diagram for 6 galaxies.

Gini-M20 results show most of our galaxies are early types. Additional dynamical analysis confirms presence of gas rich stellar disks embedded.

Galaxy Name		Redshift z	Gas Fraction [%]	SFR [log($M_\odot$/ h/yr)]	Bulge Sérsic n	Bulge Effective Radius [arcsec]	Disk Sérsic n	Disk Effective Radius [arcsec]
5	CW	6	45	30.66	7.7	0.05	1.9	0.16
	VW		87	24.4	7.0	0.03	1.2	0.26
15	CW	4	40	35.1	0.4	0.04	0.6	0.22
	VW		85	8.3	0.4	0.04	0.5	0.25
4	CW	6	44	57.54	0.2	0.07	1.3	0.33
	VW		87	13.5	0.2	0.06	0.3	0.27
20	CW	2	20	21.9	8.5	0.03	2.5	0.2
	VW		78	7.0	0.4	0.05	0.6	0.18

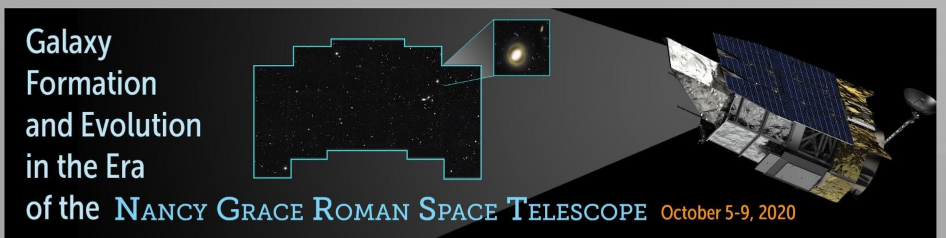
Table 2. Properties of 4 galaxies at different redshifts (including 2-component decomposition results) .

Conclusions:

All conclusions are preliminary, We find that rather than DM processes shaping the inner, central galaxies, baryonic (hydrodynamical) effects shape the galaxies (galactic winds), their gas fraction, star formation rate and galactic morphology. Galaxies with the CW tend to have more clumpy stellar structures, while galaxies with the VW develop nuclear bars and rings.

References:

[1]:Hopkins, P.E., 2017, MNRAS, 480(1), 800-863.
[2]:Springel, V., Hernquist, L. 2003, MNRAS, 339(2), 289-311.
[3]:Choi, J., & Nagamine, K. 2010, MNRAS, 407, 1464.
[4]:Camps, P., Baes, M. 2020, Astronomy & Computing, 100381.
[5]:Lotz, J. M., Primack, J., Madau, P. ,2004, AJ, 128(1), 163.
[6]:Rodriguez-Gomez et al,2019, MNRAS, 483(3), 4140-4159.



This work used XSEDE resources, which are supported by the NSF grant ACI-1548562 and the University of Kentucky LCC Cluster