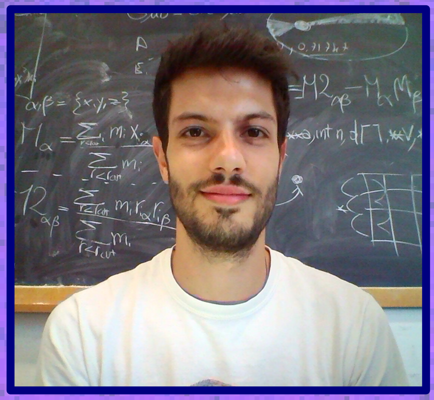

Bar formation in a cosmological context: a dynamical insight

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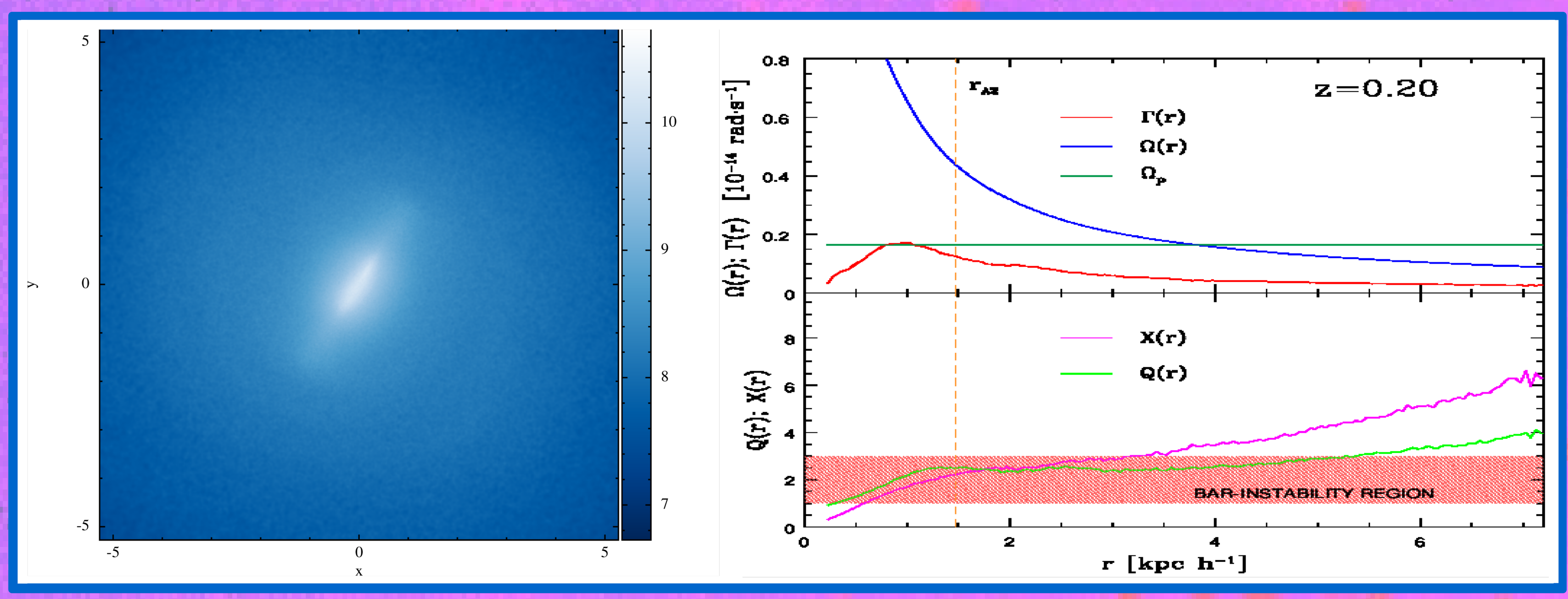
Abstract

Bars play undoubtedly a fundamental role in disc galaxy evolution. Indeed they can alter considerably the stellar and gaseous distribution if a galaxy is evolving in isolation, exerting in this way a major influence over galactic evolutionary history (Shlosman et al., 1989, Gavazzi et al., 2015).

We present here our first results of a study focused on the causes of bar formation in a cosmological frame: taking advantage of the *ErisBH* simulation (Bonoli et al. 2016) and of the *ChaNGa* code (Menon et al., 2015), we numerically investigated the impact that minor mergers can have on disc galaxies. In details, the dominant galaxy in *ErisBH* does form a bar-like structure at low redshift and this allowed us to produce two slightly different initial conditions based on a *ErisBH* snapshot at *z ~ 1.8.* We then analysed the effects of the different merger histories on the development of non-axisymetric features with controlled conditions.

Motivation



Only recently zoom-in cosmological simulation allowed to study the process resulting in the formation of a bar and its feedback on the galactic disc. In particular, *ErisBH* is a high-resolution cosmological hydrodynamical simulation which can resolve the internal structures of a Milky Way-type galaxy from $z = 90$ up to $z = 0$.

At $z = 0$ the galaxy shows a strong nuclear bar of about *2* kpc in radius which heavily affects the disc dynamics and the star formation rate in the inner region (Spinoso et al. 2016).

Figure 1. Left panel: face-on projection of the central galaxy stellar density in the ErisBH simulation at $z \sim 0.2$. Right panel: frequency plot (Γ is the precessional frequency, Ω is the angular velocity) and stability parameters Q (Toomre parameter) and X (swing amplification parameter). The bar extent is marked by the orange vertical line. (Spinoso et al. 2016).

What causes a bar?

- ***Internal secular evolution***
- ***Tidal interactions***

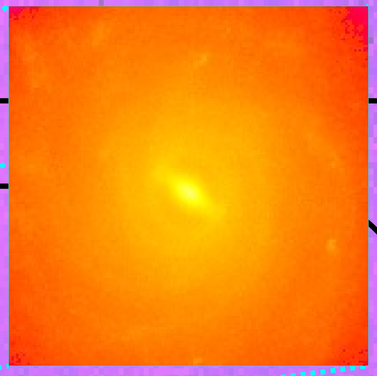
Today it's not clear what is the mechanism which triggers bar formation, so we performed these simulations to study the origin of the bar in ErisBH.

The code

ChaNGa is a cosmology simulation application built on the SPH code Gasoline (Wadsley, Stadel, Quinn, 2004) and implemented with the *Charm++* libraries. *ChaNGa* offers the possibility to examine a wide dynamical range and huge density contrast through the maximal and optimal use of computing resources.

Results

Figure 2. The snapshots compare three moments of the galaxy histories up to $z = 0$, where the bar is clearly visible. The left side of each image presents the stellar (upper panels) and gaseous (lower panels) map density of the galaxy (face-on projected) which undergoes a merger. In the simulation shown on the right side of the images the merger has been removed.



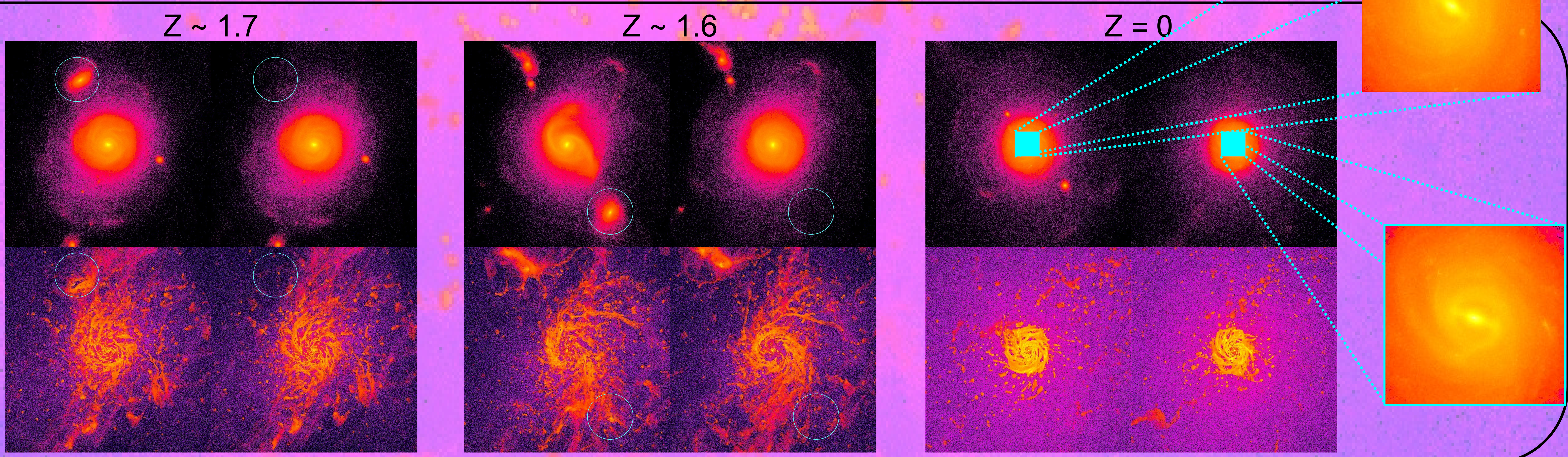


Figure 3. Upper panel: maximum amplitude of the function $A_2(R)$. Lower panel: cylindrical radius where $A_2(R)$ has the maximum. The merger and the fly-by passages are marked.

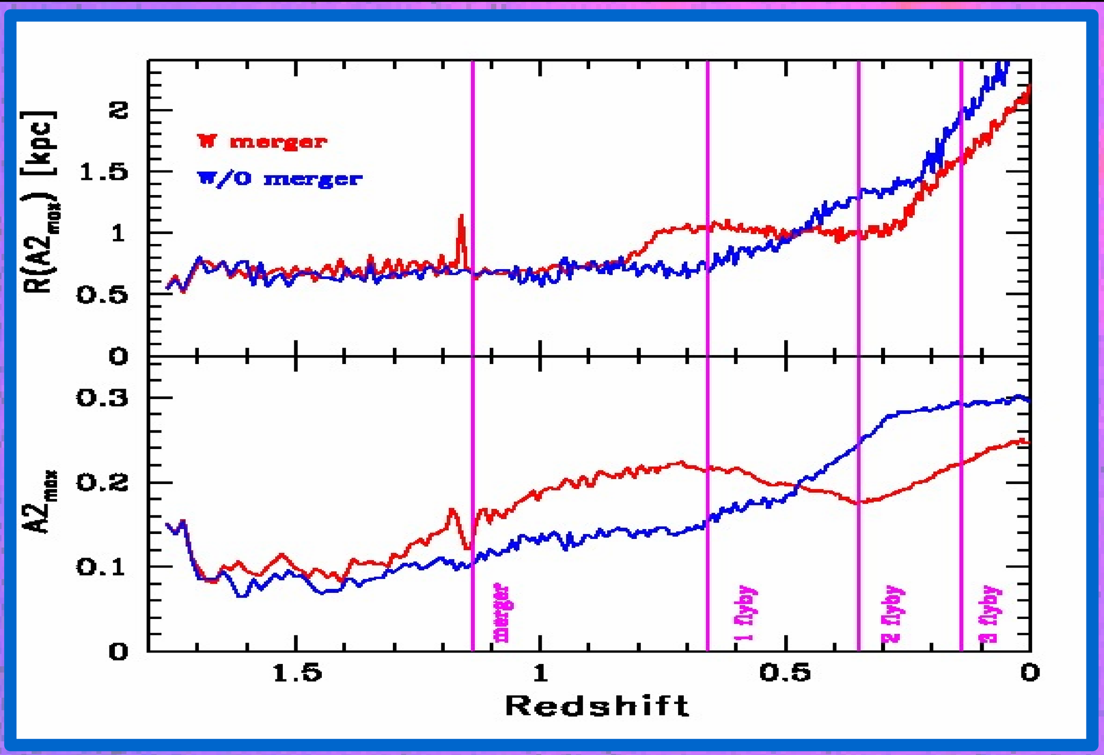


Figure 3 shows the values of the maximum of $A_2(R) = \frac{\left|\sum_j m_j e^{2i\theta_j}\right|}{\sum_j m_j}$, the second component ($m=2$) of the Fourier series we used to decompose the stellar mass distribution projected on the galactic plane. The radial position of the maximum is used to estimate the bar extent (Dubinski, Berentzen & Shlosman, 2009).

In addition to the main merger (removed in the second run) we found a second relevant dynamical event due to a fly-by (enlighted in the figure).

The postponed growth of the bar in the second case seems to be related to this event.

Follow ups

1) Deeper analysis of the early bars
2) Repeat the simulation after isolating the fly-by
3) Large cosmological run with multiple field disc galaxies (PRACE in progress)

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