DARK MATTER BAR EVOLUTION WITHIN BOTH TRIAXIAL AND SPINNING HALOES

Daniel A. Marostica & Rubens E. G. Machado

Universidade Tecnológica Federal do Paraná

marostica@alunos.utfpr.edu.br

Abstract

The shape of dark matter bars is subject to several evolutionary factors. Two of the most determining are the dark matter halo triaxiality and spin. In this study, we aim to inspect and compare simulated galaxies with different halo triaxialities and halo spin parameters, in order to understand how these variables affect the secular evolution of the stellar bar and the dark matter bar. Using N-body simulations, we calculate the bar strength for galaxies with initially spherical and triaxial live haloes. We run the analysis also for spherical haloes with different spin parameters. We find that both the stellar and the DM bars are stronger in the case of a spherical halo, whereas somewhat weaker for increasing halo triaxiality. Increasing spin drives a premature strengthening of both bars, and results in stronger peaks of DM bars.

Introduction

Dark matter bars form inside haloes of strongly barred galaxies. They have been well-studied in the past few decades, but the rich dynamical interplays under which the bars are formed open ways to discover yet unknown features. For example, if the haloes are non-spherical or have different spin parameters, the inner dark matter bar will evolve differently and, most importantly, have a different final structure (Collier et al., 2019).

Methodology

Using colisionless N-body simulations with 10^6 halo particles and 2×10^5 disk particles, we set different triaxialities and spin parameters (λ) to two groups of galaxies (see Table 1): galaxies 1, 2 and 3; galaxies 1, 4 and 5. The simulations were carried out with GADGET-2 (Springel, 2005). We obtained values for the strength of the bars and studied the evolution of the angular momentum transfer.

Table 1: Simulation specifications. Spinless galaxies 1, 2 and 3 use the same initial conditions as some of Athanassoula et al. (2013), whereas galaxies 4 and 5 have the spherical halo of galaxy 1, from which we had the tangential velocity of some particles inverted, thus producing a net spin.

alias	b/a	c/a	λ
galaxy 1	1.0	1.0	0.00
galaxy 2	0.8	0.6	0.00
galaxy 3	0.6	0.4	0.00
galaxy 4	1.0	1.0	0.03
galaxy 5	1.0	1.0	0.07

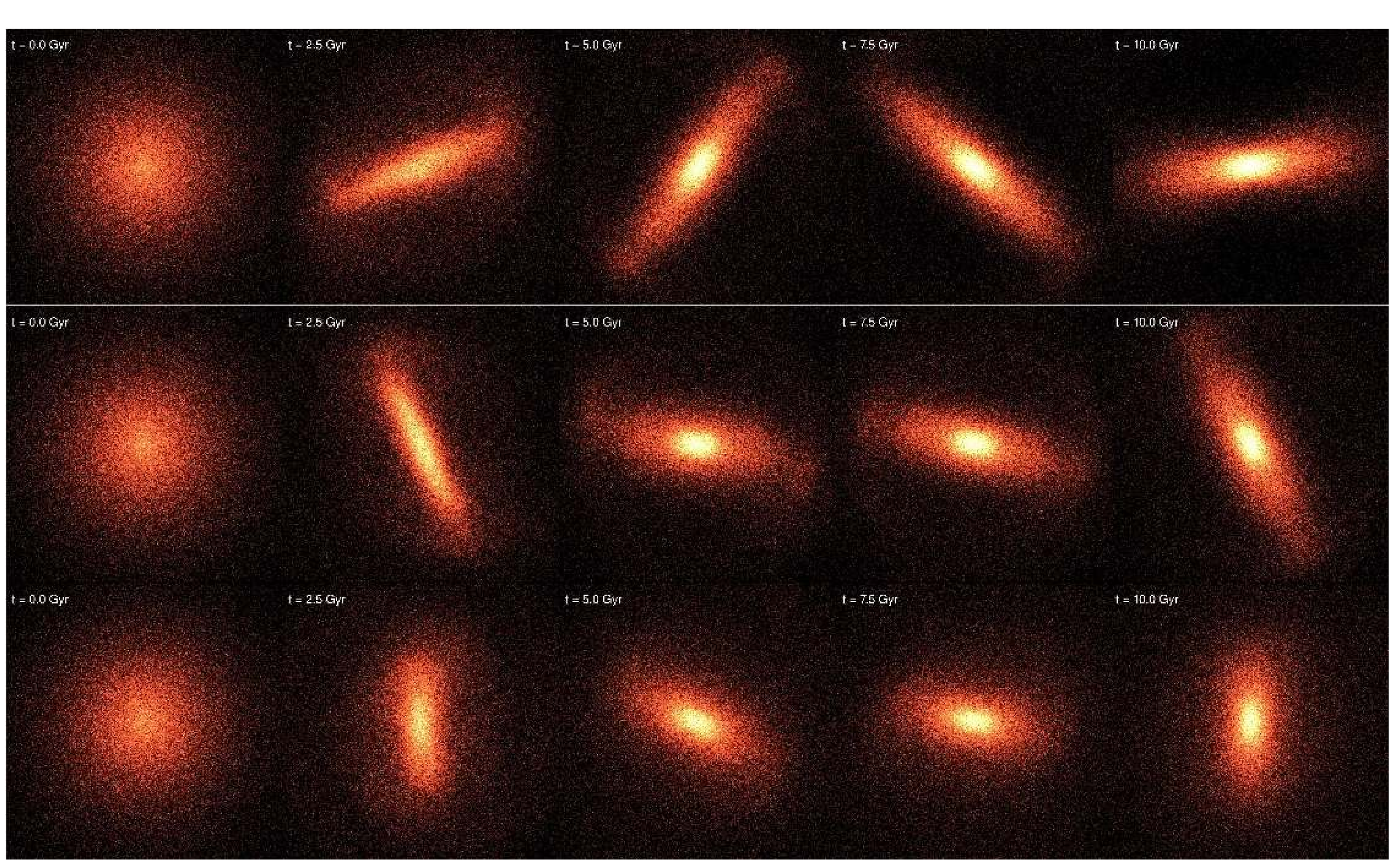

Figure 1: Time evolution of the disc bars embedded in different spinning haloes. From top to bottom, galaxies 1, 4 and 5. Each frame is 20 kpc wide.

Results

Regarding halo shapes, we find that the stellar bar is stronger in the case of a spherical halo and somewhat weaker for increasing halo triaxiality (Fig. 2). The halo bar is also weaker in the triaxial haloes. With regard to halo spin, we find that bars strengthen earlier in faster spinning haloes and may dissolve after the occurence of buckling instabilities (Fig. 3). Haloes with considerable spin are unable to absorb as much angular momentum as a non-spinning one; in fact, they even lose it (Fig. 4), resulting in stronger halo bars.

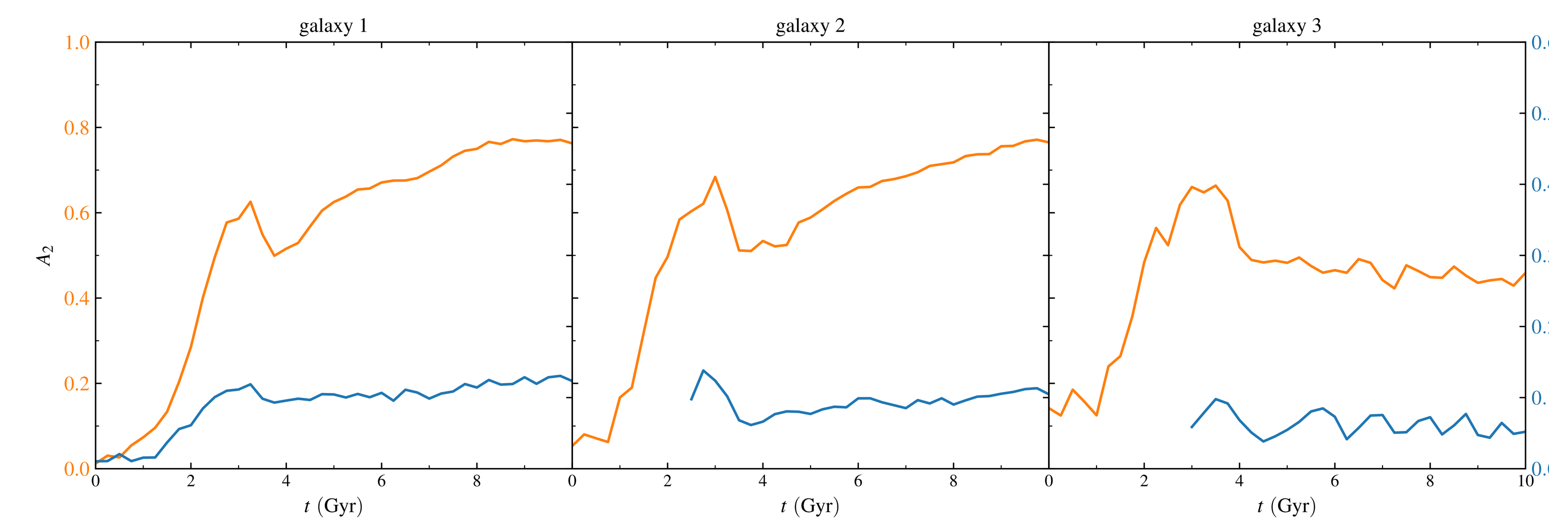

Figure 2: Evolution of bar strength for spinless halo models with different halo triaxialities (1, 2 and 3). The stellar disc bar strength (orange) of galaxy 1 peaks at about the same value for the triaxial haloes of galaxies 2 and 3. The dark matter halo bar strength (blue, with a different scale on the right axes) decreases with increasing halo triaxiality.

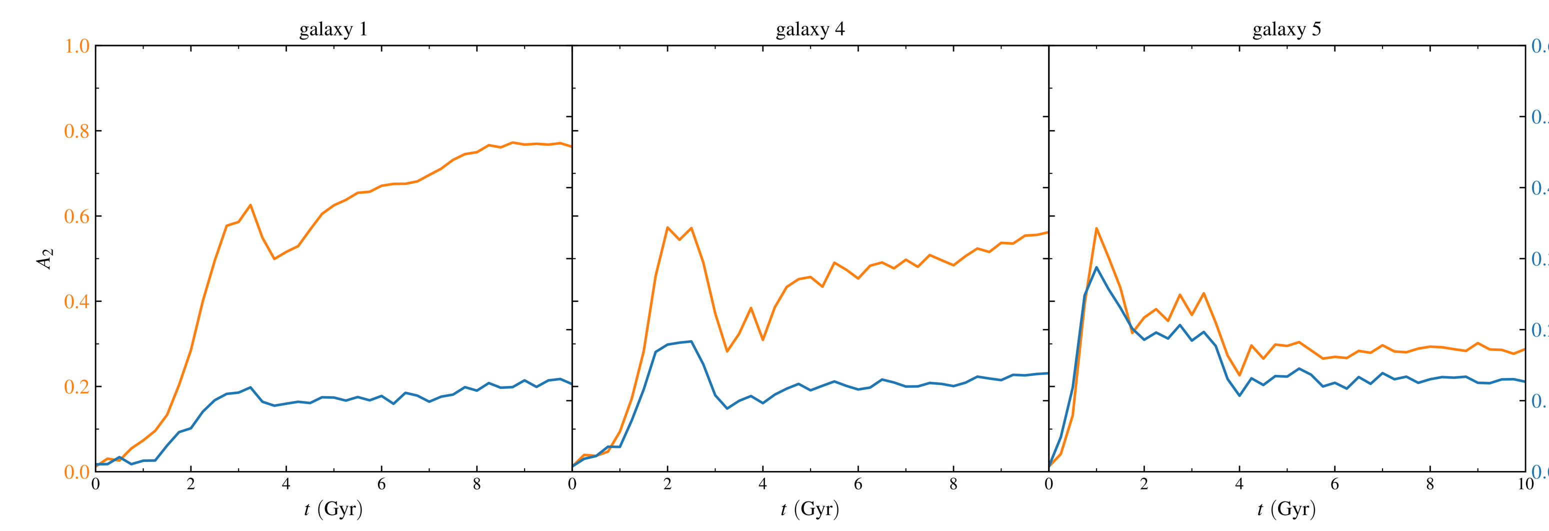

Figure 3: Evolution of bar strength for spherical halo models with different spins (1, 4 and 5). The stellar disc bar strength (orange) peaks at a slightest smaller value for the spinning haloes 5 and 6. On the other hand, the dark matter halo bar strength (blue, with a different scale on the right axes) significantly increases with halo spin and the buckling instabilities occur earlier and are more destructive.

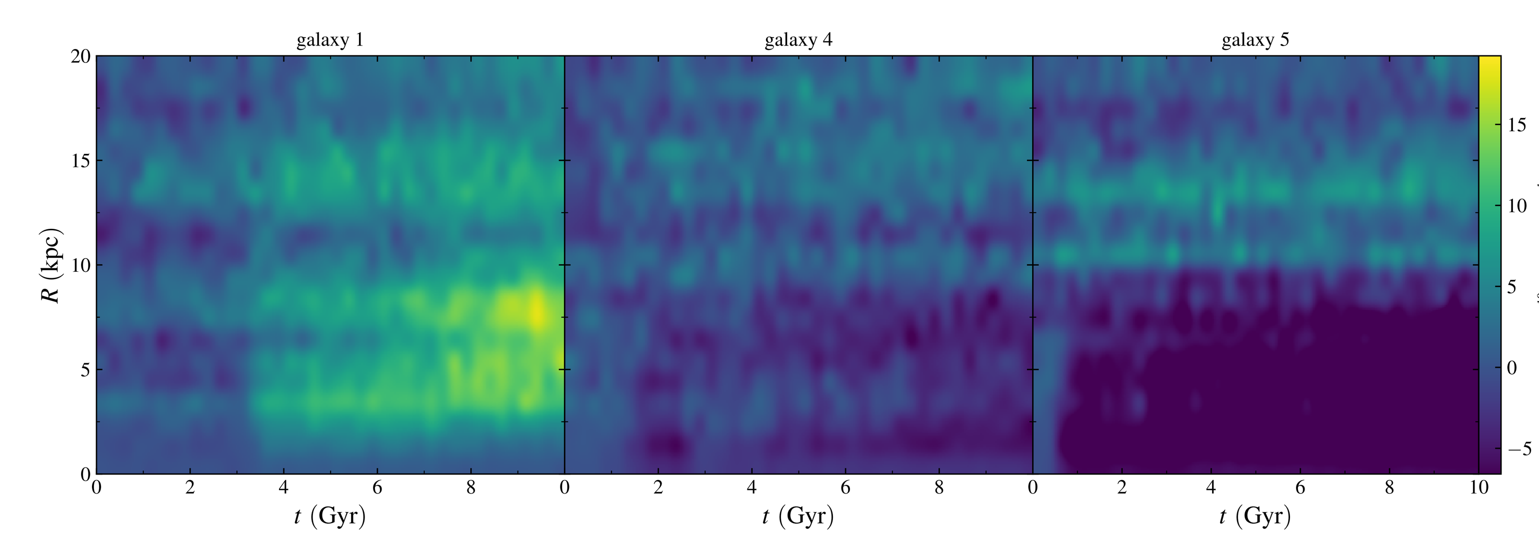

Figure 4: Transfer of angular momentum within the dark matter halo, for galaxies with different spin parameters. Namely, distance to the center of the galaxy as a function of time. Colors represent angular momentum gain (yellow) or loss (purple).

Conclusion

We find that both the dark matter and the stellar bars of these simulations are weaker when embedded in triaxial haloes, if compared to the spherical cases. This is connected to the lower amount and rate of angular momentum transfer from disc to halo.

Spinning haloes drive premature stellar bar strengthening, which in turn are less likely to survive the buckling stage and regain strength. Their dark matter bars lose angular momentum.

Acknowledgment

Bolsista CNPq

References

Athanassoula E., Machado R. E. G., Rodionov S. A., 2013, MNRAS, 429, 1949

Collier A., Shlosman I., Heller C., 2019, MNRAS, 488, 5788

Springel V., 2005, MNRAS, 364, 1105