Proceedings for: the Interplay between Local and Global Processes in Galaxies
Cozumel, México, 11th-15th April, 2016

Dynamical Properties of Galaxies with Different Morphological Types at $z = 0$ and $z = 2$

Adelheid F. Teklu[1,2], Rhea-Silvia Remus[1], & Klaus Dolag[1,3]

[1]Universitäts-Sternwarte München, LMU München, Scheinerstr. 1, D-81679 München, Germany
[2]Excellence Cluster Universe, Bolzmannstr. 2, D-85748 Garching, Germany
[3]Max-Planck-Institute for Astrophysics, Karl-Schwarzschild-Str. 1, D-85741 Garching, Germany
e-mail: ateklu@usm.lmu.de

Over the past decades the connection between the angular momentum of dark matter halos and their galaxies' has been discussed in several studies. In a hierarchical ΛCDM universe, structures grow through accretion of smaller substructures, but at the very beginning the gas cools and collapses into the dark matter halos to form the stars and galaxies at their centers. In this process, both components, gas and dark matter, gain a similar amount of angular momentum through tidal torques, albeit the gas can transport the angular momentum to the center of the halo. We use galaxies selected from the Magneticum Pathfinder Simulations to investigate the correlation of the specific angular momentum of the stars j_* and the stellar mass of both disk and spheroidal galaxies at different redshifts as well as the spin parameter of the dark component. We find that the disk and spheroidal galaxies populate different regions in the M_*–j_* plane, in agreement with observations. This split-up is already present at $z = 2$, however, the specific angular momenta are generally smaller at higher redshifts. Similarly, the bimodality between disks and spheroids can also be seen in the spin parameter distribution of the according dark matter halos.

Keywords: galaxies: evolution – formation – dark matter, method: numerical

1 Method

Since recent hydrodynamical cosmological simulations can well resolve the morphological structures of galaxies, it became possible to investigate in detail the dynamical properties of different types of simulated galaxies, distinguishing between spheroids and disk galaxies. We use the Magneticum Pathfinder Simulations[1] to study the angular momentum properties of the dark matter halos and the galaxies, especially the specific angular momentum of the stars j_* and the spin parameter λ (e.g. Peebles 1971). Here, we focus on the differences between disk and spheroidal galaxies. To distinguish between disk and spheroidal galaxies we use a classification criterion based on the circularity parameter ε (e.g. Scannapieco et al., 2008), and the fraction of cold gas (see Teklu et al., 2015, for more details). We include galaxies at two different redshifts, namely $z = 0$ and $z = 2$, in this study, with a stellar mass limit of $M_* \geq 10^{10} M_\odot$.

[1]www.magneticum.org

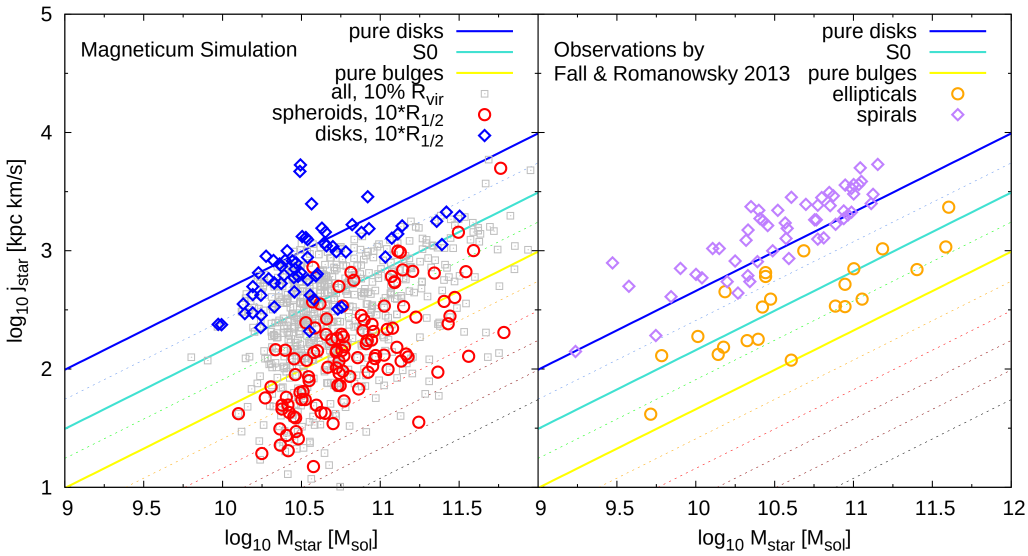

Figure 1: *Left:* the stellar mass against the stellar specific angular momentum of the disks (blue diamonds) and spheroids (red circles) in our simulation. Additionally, gray squares represent all galaxies and colored lines show the scaling relations taken from Romanowsky & Fall (2012). *Right:* the same for observations of spirals (purple diamonds) and ellipticals (orange circles) by Fall & Romanowsky (2013).

2 The M_*–j_* Relation

In good agreement with observations by Fall & Romanowsky (2013), we find that spheroids and disk galaxies populate different regions in the so-called M_*–j_* plane (see Fig. 1). Interestingly, we find that the disks and spheroidal galaxies lie almost perfectly on the scaling relations for pure disks and bulges, respectively (see Romanowsky & Fall, 2012). When looking at the whole galaxy population (gray squares) we find a continuous distribution along the M_*–j_* plane.

We find that this split-up is already present at $z = 2$, as can be seen in Fig. 2. However, the galaxies generally have a lower stellar specific angular momentum than the galaxy population at redshift $z = 0$, and it is more pronounced for disk galaxies. This shift is in good agreement with recent theoretical predictions of $j_*|_{M_*} \propto \sqrt{z+1}^{-1}$ by Obreschkow et al. (2015), see shift between dashed and solid lines in Fig. 2.

3 The Spin Parameter λ

This dichotomy is also reflected in the spin parameter λ, which includes all components and thus is a measure of the rotation of the whole halo: we also find a split-up of the two different galaxy types, where the disk galaxies, in general, tend to have higher λ-values than the spheroidal galaxies (see Teklu et al., 2015, for more details). Even in the counterpart halos of our dark matter-only run, which is exactly the same simulation but without baryons, we find this split-up of the different galaxy types (see Fig. 3). This split-up is present at $z = 0$ as well as at $z = 2$. This suggests that the halo and the morphological type of a galaxy are shaped simultaneously by the formation history and the environment. For more details, see Teklu et al. (2015).

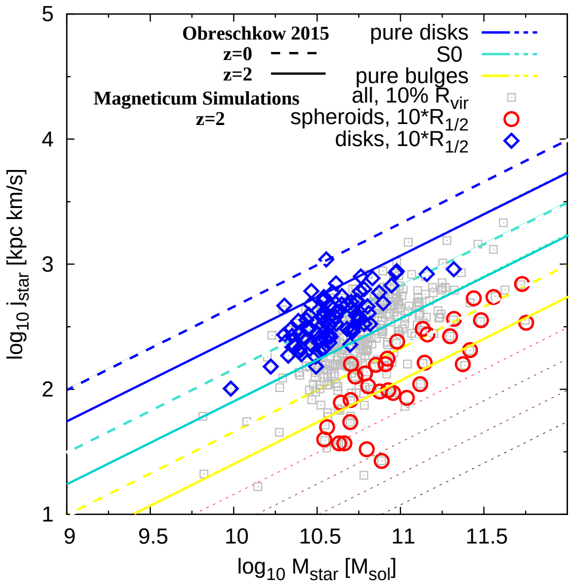

Figure 2: Same as Fig. 1 but for simulated galaxies at redshift $z = 2$. Dashed and solid lines are the predicted scalings from Obreschkow et al. (2015) for $z = 0$ and $z = 2$, respectively.

4 Conclusions

We find that our simulated disk and spheroidal galaxies populate different regions in the M_*–j_* plane, in agreement with observations at $z = 0$. This holds true for $z = 2$ as well, where the galaxies have slightly lower angular momentum, in good agreement with

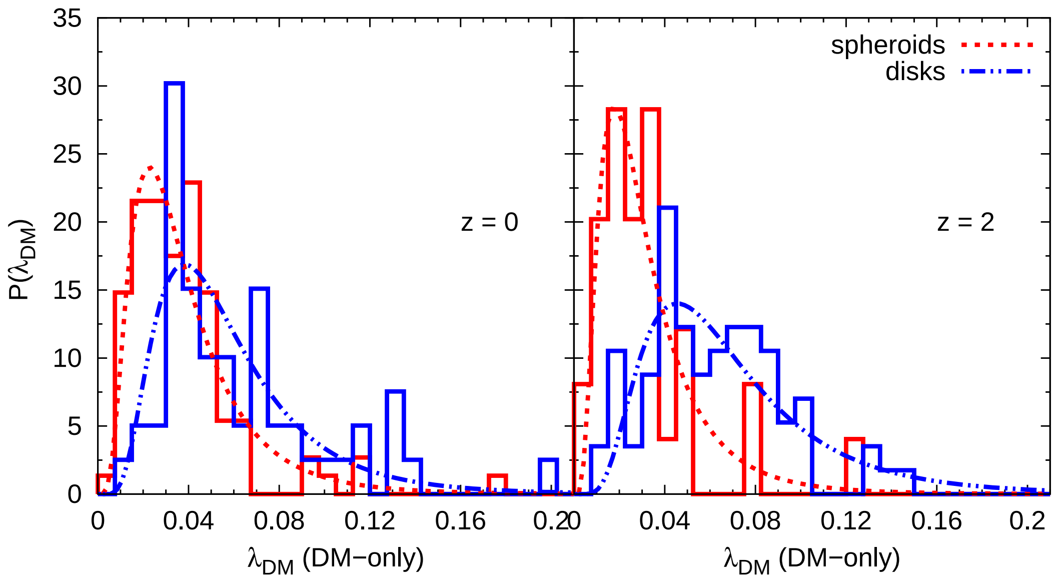

Figure 3: The distribution of the spin parameter of the dark matter component of the cross-matched disks (blue) and spheroids (red) in the dark matter-only run. In general, the disks have higher λ-values than the spheroids. *Left:* λ–distribution at $z = 0$. *Right:* λ–distribution at $z = 2$.

theoretical predictions. The split-up in the angular momentum of the different galaxy types is not only seen in the baryonic component but also in the whole halo and the dark matter component, where we find that the λ-distribution of disks has a higher median value. The fact that the split-up is even present in the dark matter-only run suggests that the formation history and the environment both shape the galaxy type and its halo.

References

Bullock J. S., Dekel A., Kolatt T. S., *et al.*, 2001, ApJ, 555, 240
Fall S. M., & Romanowsky A. J., 2013, ApJL, 769, L26
Obreschkow D., Glazebrook K., Bassett R., *et al.*, 2015, ApJ, 815, 97
Peebles P., 1971, A&A, 11, 377
Romanowsky A. J., & Fall S. M., 2012, ApJS, 203, 17
Scannapieco C., Tissera P., White S., & Springel V., 2008, MNRAS, 389, 1137
Teklu A. F., Remus R.-S., Dolag K., *et al.*, 2015, ApJ, 812, 29