Forming Disc Galaxies in Major Mergers: Radial Density Profiles and Angular Momentum

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Our simulations

Using **high-resolution N-body simulations** (>5 million particles), we show that gas-rich major mergers can produce realistic disc galaxies (**Athanassoula et al. 2016**).

Our simulations start from two spherical protogalaxies consisting only of a **gaseous** and a **dark matter** halo. A stellar disc and a bulge form in each progenitor, which are destroyed by the merging. A new disc then forms in the remnant galaxy by newly born stars from accreted halo gas, with realistic dynamics and morphology (Fig. 1).

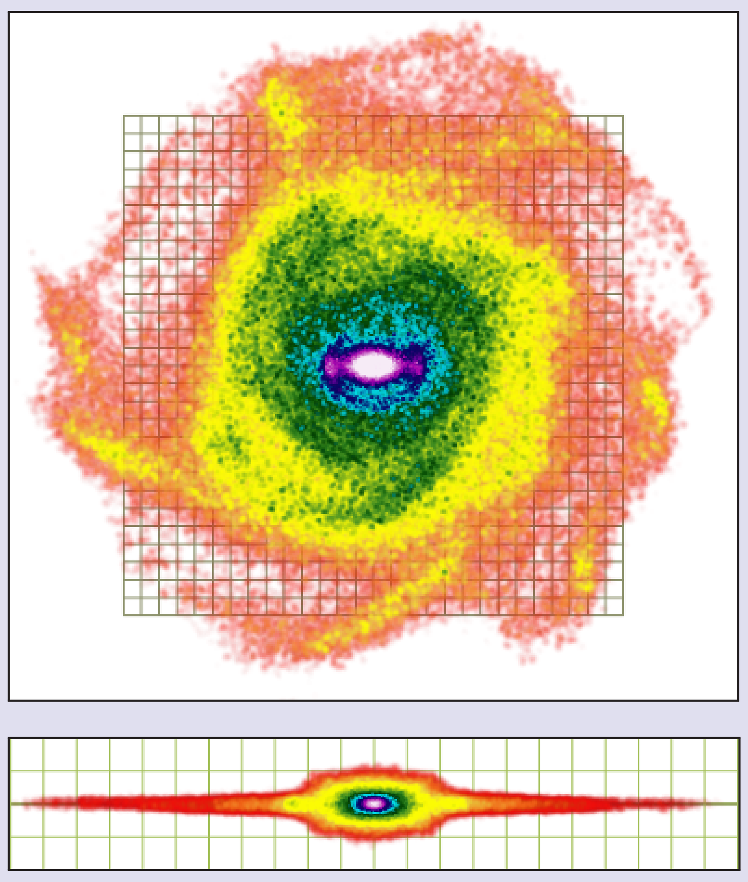
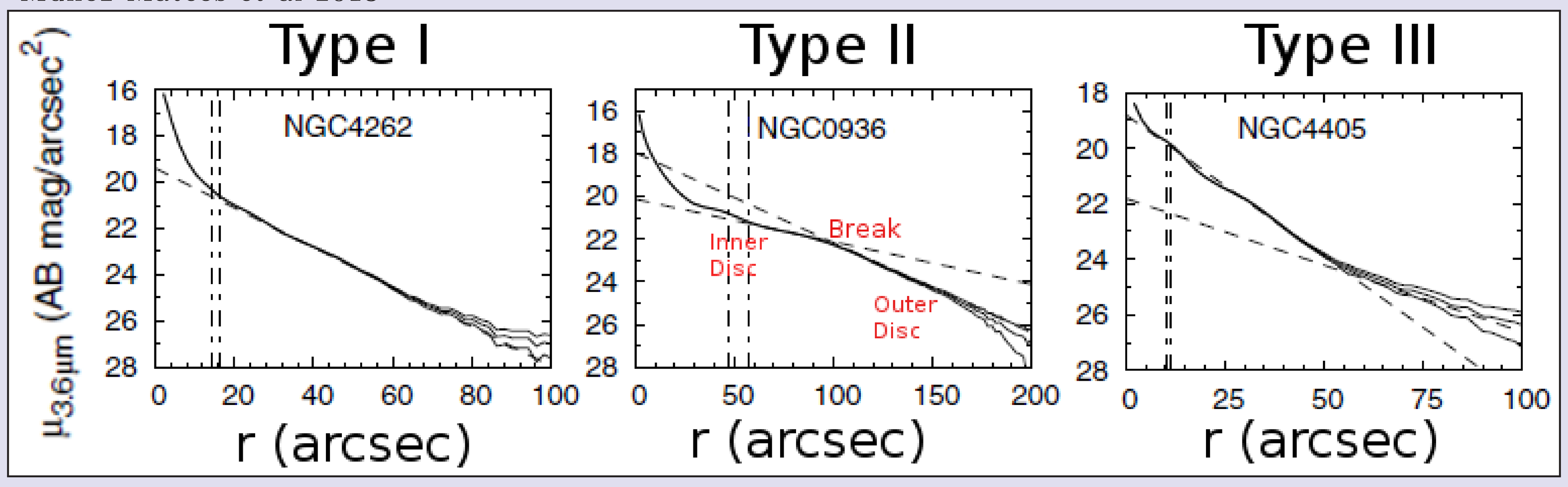


Fig. 1. Face-on (top) and edge-on view (bottom) of the galactic density.

Radial density profile

We look at the **stellar radial density profile** of the galaxy, and in particular at the disc part. 3 types of profiles can be found in disc galaxies:

Munoz-Mateos et al 2013



single exponential | broken exponential downbending | broken exponential upbending

Our simulations show **mostly type II discs** (downbending), and some type III (upbending). We fitted those profiles, to get the values of the **disc scalelengths** (inner and outer), and the **break radius**.

Radial Density Profile and Global Angular momentum

How is the surface density profile of a disc galaxy affected by the total angular momentum? (Peschken et al. 2017)

As a definition of the total angular momentum, we use the global dimensionless **spin parameter** λ, and look how in type II discs the disc scalelengths (inner and outer discs) and the break radius behave for different values of λ. Using our sample of **132 simulations**, we find that **higher angular momentum galaxies have larger disc scalelengths and break radius** (Fig. 2).

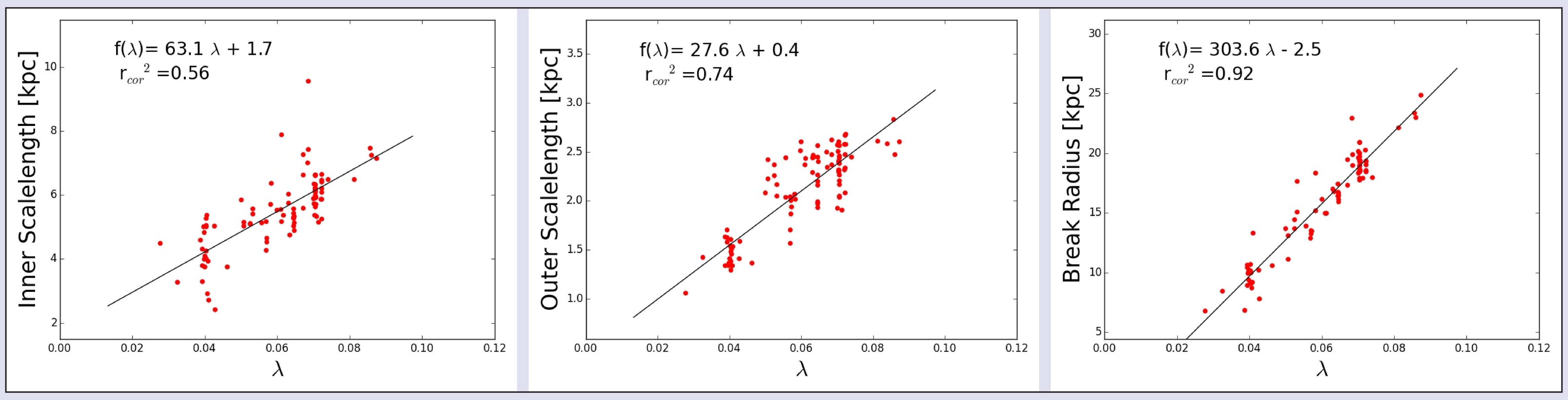


Fig. 2. Inner disc Scalelength, Outer disc Scalelength and Break Radius as a function of the spin parameter λ, for our sample of simulations. Each point represents a different simulation, and a linear fit is performed in black, with the corresponding parameters written on the top.

This means that in galaxies with high angular momentum, **the inner disc and the outer disc will be flatter, and the break will be located further out** (Fig. 3).

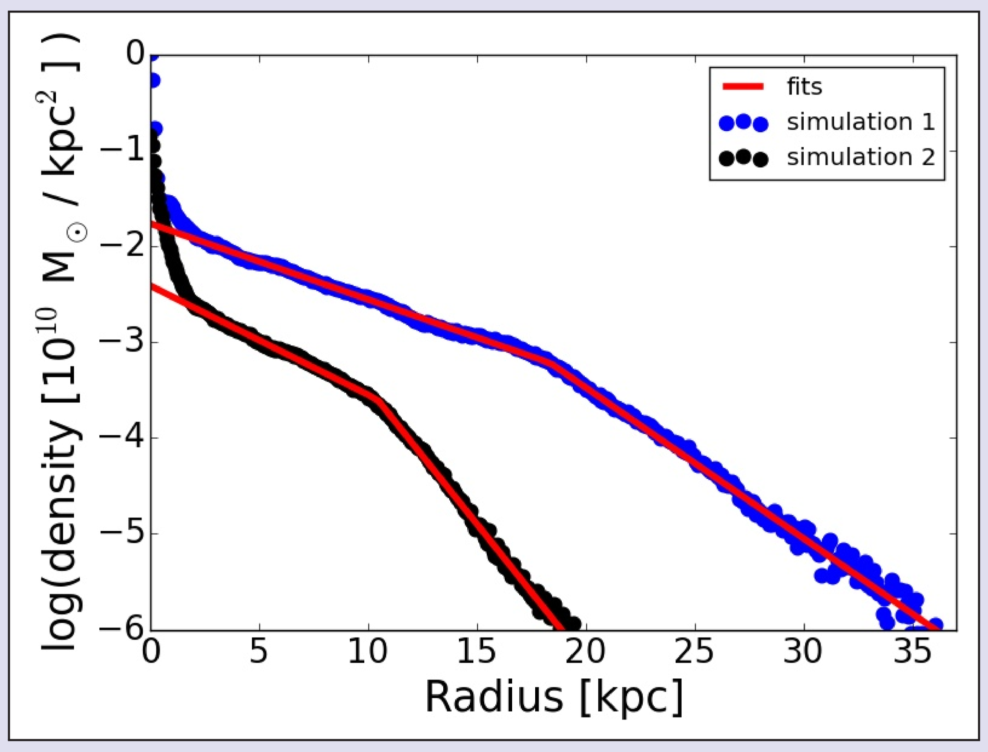


Fig. 3. Radial density profile for 2 simulations, simulation 1 having more angular momentum than simulation 2.

Therefore, the amount of **angular momentum in a galaxy can explain the large scatter of disc scalelengths and break radius values observed in real galaxies** at a given mass.

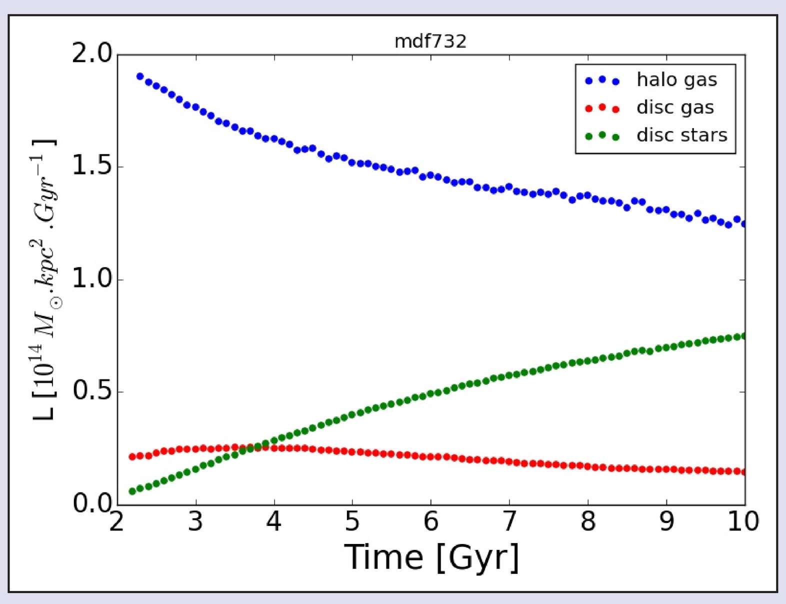
We find these correlations to be valid for different initial parameters, as well as for galaxies evolved in isolation.

Angular Momentum redistribution

How to explain this correlation between the global halo-dominated angular momentum of the galaxy and the disc density profile? (Peschken et al. 2017)

We show that in our simulations, the angular momentum in the stellar disc is gradually acquired to the detriment of the surrounding gaseous halo, by **gas accretion** and subsequent star formation in the disc (Fig. 4).

Fig. 4. Total angular momentum of the halo gas, disc gas and disc stars as a function of time, for one simulation after the merger.



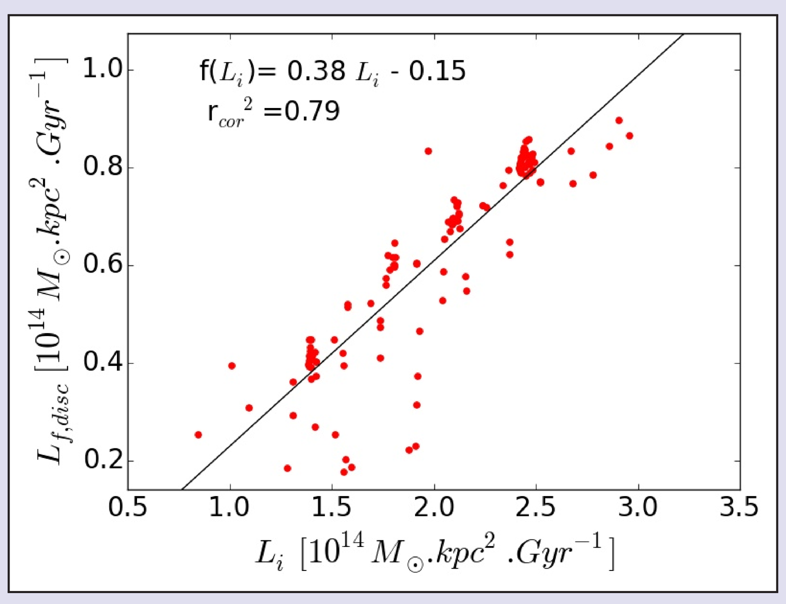


Fig. 5. Angular momentum of the final baryonic disc as a function of the total initial baryonic angular momentum, for our sample of simulations.

Furthermore, **high angular momentum systems transfer more angular momentum to their discs** (Fig. 5).

Therefore, systems with more angular momentum create discs having also more angular momentum, which has a direct impact on their stellar density distribution.

Conclusions

- Our simulations show that major mergers can produce disc galaxies with realistic features.
- Most of the radial stellar density profiles in our galaxies show downbending discs (type II).
- The disc scalelengths of both the inner and the outer disc, as well as the break radius, all increase linearly with the total galactic angular momentum for type II discs.
- The disc angular momentum is acquired by accretion from the gaseous halo.
- Galaxies with more angular momentum transfer more angular momentum to their discs, which directly affects the density distribution.

References

- Athanassoula E., Rodionov S. A., Peschken N., Lambert J. C., 2016, ApJ, 821, 90
- Peschken N., Athanassoula E., Rodionov S. A., 2017, MNRAS, 468, 994