The sizes of ultramassive galaxies: a dark matter perspective

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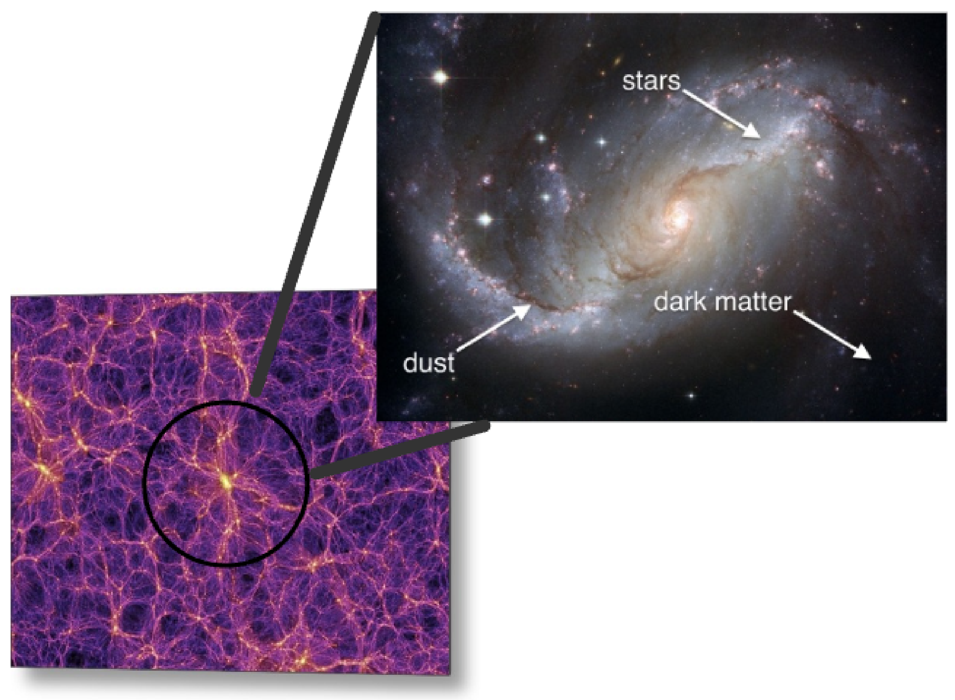
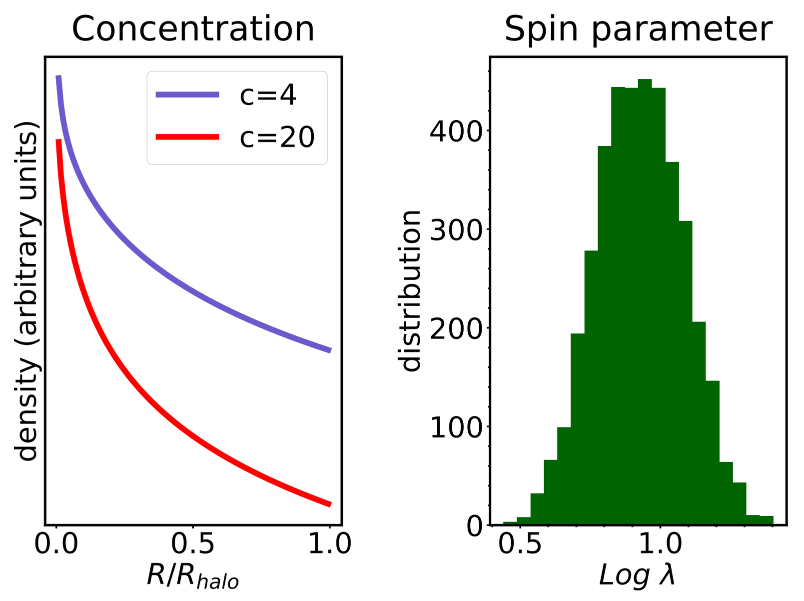
1 Galaxies and dark matter

Galaxies are made of **stars**, **dust**, **gas** (these are called *baryons*) and the elusive **dark matter**. The baryonic physics is extremely complex and very difficult to model accurately.



The **dark matter halo** in which galaxies live, extends far outer than the luminous matter. Contrary to galaxies, dark matter halos are extremely simple objects that have only 4 properties: **mass**, **size**, **spin parameter** λ (related to the rotation of the halo) and **concentration** (a structural parameter). The border of a halo is defined by its **radius** R_{halo}. matter halos grow in time by accreting other dark matter in their outskirts from the *cosmic web.* Galaxy physics is tightly linked to that of their dark matter halos: *galaxies and their host halos co-evolve*.

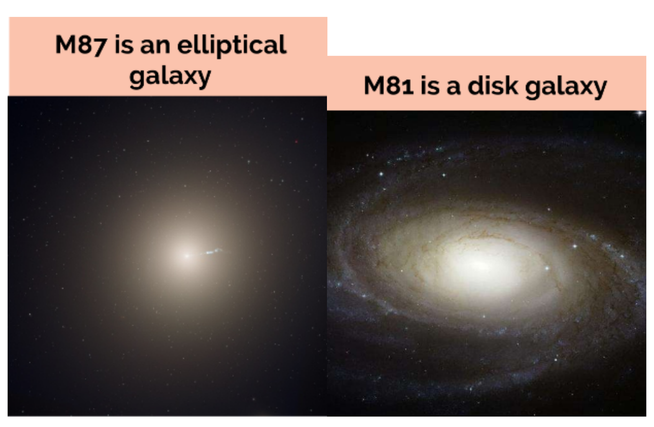


2 The sizes of ultramassive galaxies

The size of a galaxy R_{gal} is defined as the the radius that encloses half the galaxy light. Galaxies that have a certain mass typically had smaller sizes when the Universe was younger: *size evolution.*

The most massive galaxies in our Universe have masses larger than 100 billion solar masses. They are quite common in today's Universe, but were much rarer in the past. These galaxies were 3 to 5 times smaller 11 billion years ago, and hence they were much more *compact*.

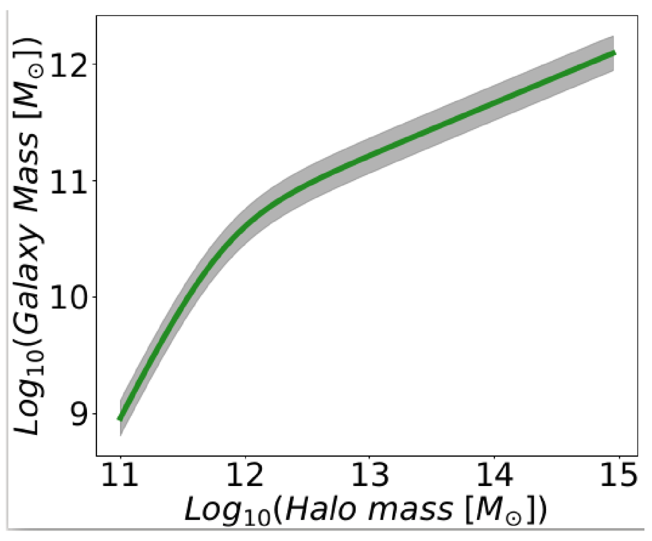
In the nearby Universe, ultramassive galaxies may be ellipticals or spirals. Current theories predict that for disk galaxies $R_{gal} \propto \lambda R_{halo}$. The size distribution of the population will then follow from that of the spin parameter λ.



3 Methods: an observationally driven model

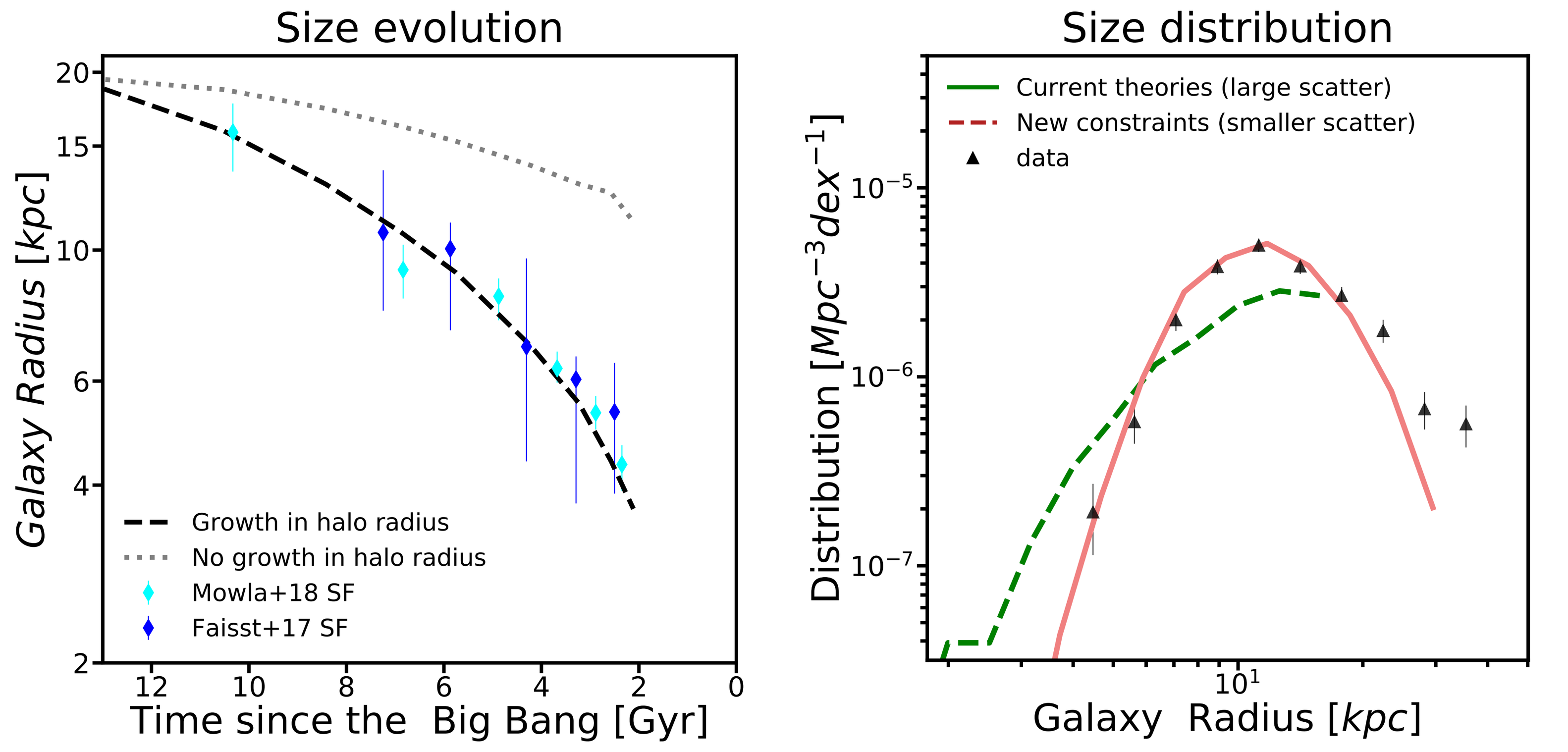
Can models of galaxy sizes based on dark matter properties reproduce observations?

1. We take dark matter halos from dark matter simulations
2. We place a galaxy in each halo so that more massive galaxies live in more massive halos
3. Each galaxy is assigned a size according to the dark matter halo properties:



we always assume that **the galaxy radius is equal to a given fraction of the halo radius**: $R_{gal} \propto R_{halo}$. We either adopt the standard theory (see box 2) or we adjust a parameter of the model known as *intrinsic scatter* until it matches observations.

4 Model results



- **Size evolution**: *No growth in halo radius:* $\Longrightarrow$ *No growth in galaxy radius*, (residual evolution is due to statistics - larger halos form).
- **Size distribution**: Standard theories strongly disagree with data for ultramassive disk galaxies. We give new constraints in terms of the intrinsic scatter.

5 Conclusions

1. Size evolution: Both models reproduce data. *Moreover, the size evolution of ultramassive galaxies is mostly driven by the growth of their host halo.*

2. Size distribution: *The width of the observed size distribution is much lower compared to that predicted by standard theories:* ***we give new constraints on models***.

Image credits: ESA/NASA HST, The millenniums Simulation Project