Dynamical Properties of Galaxies with Different Morphological Types

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The Interplay between Local and Global Processes in Galaxies, Cozumel
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The Magneticum Pathfinder Simulations

- different galaxy types
- 68.5 Mpc

Relation to
- dark matter
- dynamics

see poster by K. Dolag
The Magneticum Pathfinder Simulations

different galaxy types

68.5 Mpc

Romanowsky & Fall 2012

log (j*) [km s⁻¹ kpc]

log (M* / M☉)

pure disks

S0

S0a

Sb

Sc

B/T = 0.0

0.2

0.4

0.6

0.8

1.0

pure bulges

100 kpc
The Magneticum Pathfinder Simulations

- different galaxy types
- 68.5 Mpc

Graph showing:
- pure disks
- S0
- pure bulges

Equation: $y = ax + b$ with $a = 2/3$

Axes:
- $\log_{10} I_{\text{star}}$ [kpc km/s]
- $\log_{10} M_{\text{star}}$ [$M_{\odot}$]

100 kpc
Classification

\[ \varepsilon = \frac{j_z}{j_{\text{circ}}} = \frac{j_z}{rV_{\text{circ}}} \]

\[ V_{\text{circ}} = \sqrt{GM(r)/r} \]

\[ \varepsilon = 0 \rightarrow \text{dispersion dominated} \]

\[ \varepsilon = 1 \rightarrow \text{rotation dominated} \]

(e.g. Scannapieco et al. 2008)
Classification

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(e.g. Scannapieco et al. 2008)

Criteria at \( z=0.1 \):

\[ f(|\varepsilon| \leq 0.4) \geq 0.6 \text{ and } M_{\text{cold gas}} / M_{\text{star}} \leq 0.065 \rightarrow \text{Spheroid} \]

\[ f(\varepsilon \geq 0.7) \geq 0.4 \text{ and } M_{\text{cold gas}} / M_{\text{star}} \geq 0.215 \rightarrow \text{Disk} \]

Teklu et al. 2015
**Comparison to Observations**

**Simulation**

Magneticum Simulation
- pure disks
- S0
- pure bulges
- all, 10% $R_{\text{vir}}$
- spheroids, 10$^*R_{1/2}$
- disks, 10$^*R_{1/2}$

**Observation**

Observations by
Fall & Romanowsky 2013
- pure disks
- S0
- pure bulges
- ellipticals
- spirals

![Graph showing comparison between simulation and observation](image.png)
Spin Parameter of Host Halo
(including all components - DM, gas & stars)

Split-up into spheroids and disks!

\[ \lambda = \frac{J |E|^{1/2}}{GM^{5/2}} \]

\[ E = -\frac{GM^2}{2R_{\text{vir}}} \]

(Peebles 1969/71, Mo et al. 1998)
Spin Parameter of Host Halo
(including all components - DM, gas & stars)
Split-up into spheroids and disks!

\[ \lambda = \frac{J |E|^{1/2}}{GM^{5/2}} \]
\[ E = -GM^2/2 R_{\text{vir}} \]

(Peebles 1969/71, Mo et al. 1998)

Already present at \( z = 2 \)!
Spin Parameter of the DM-component

Implications:
- interplay between baryons and DM
or
- due to different formation histories

Modified Spin Parameter:
\[ \lambda_{DM} = \frac{j_{DM}}{\sqrt{2}R_{vir}V_{circ}} \]
\[ V_{circ} = \sqrt{GM/R_{vir}} \]

(Bullock et al. 2001, van den Bosch et al. 2002)
Cross-Matching Halos DM-only vs. Hydro

Criteria:
- $d < 200 \text{kpc}$
- mass difference $< 30\%$

Cross-matched: $575/622$

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Teklu et al. 2015
Spin Parameter of DM-only Halos

Even here is a split-up of different galaxy types → morphology a result of formation history/environment?
Summary and Conclusion

- Our simulated disks and spheroids populate different regions in the $M_{\text{star}}-j_{\text{star}}$ plane, in agreement with observations.

Disks have higher median spin parameter compared to spheroids.

- There are also spheroids with high $\lambda$ (for detailed study see Schulze et al., in prep.).

- Even in DM-only a split-up of $\lambda$-distribution

  → Formation history and environment shape simultaneously galaxy type and halo

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Teklu et al. 2015
In the hydro run DM components (inner part with total halo) are better aligned than in DM-only run → influence of baryons on DM
Spin Parameter of Different Components

Split-up of:

stars, DM and gas  hot and cold gas
how disk components (stars and gas) trace, how halo and disk (dm and gas) trace...

![Diagram showing correlations between different stellar and gaseous components.](image-url)
The Dependence of the b-value on Radius

For spheroidal galaxies the measurement of the b-value is strongly radius-dependent.
Threshold for epsilon-Classification

- For ellipticals
- For disks

$z = 0.1$
Gas Fractions

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Teklu et al. 2015
Stellar Mass Functions

\begin{figure}
\centering
\includegraphics[width=\textwidth]{stellar_mass_function.png}
\caption{Stellar Mass Function in the range 0.0 \leq z \leq 0.2.}
\end{figure}

Remus et al. 2015