ASTROPHYSIKALISCHES INSTITUT POTSDAM

AIP

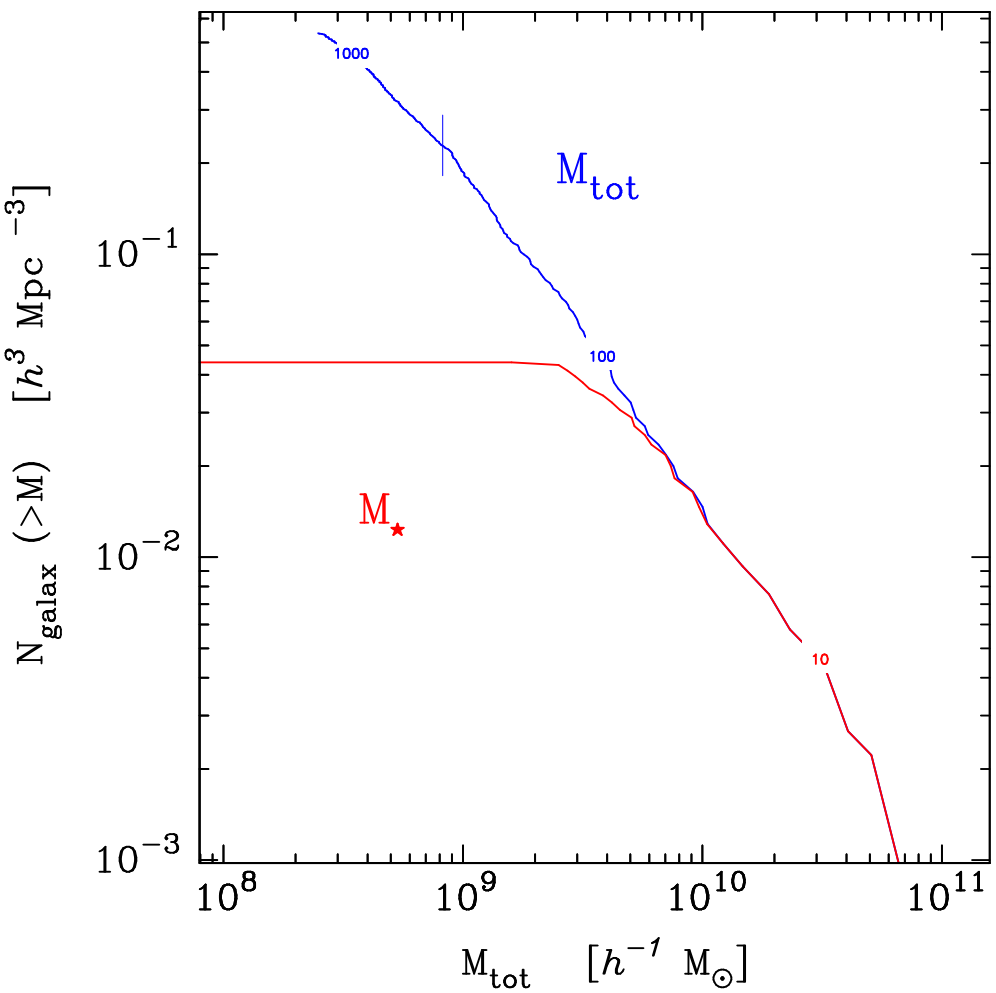
The structure of dark matter halos

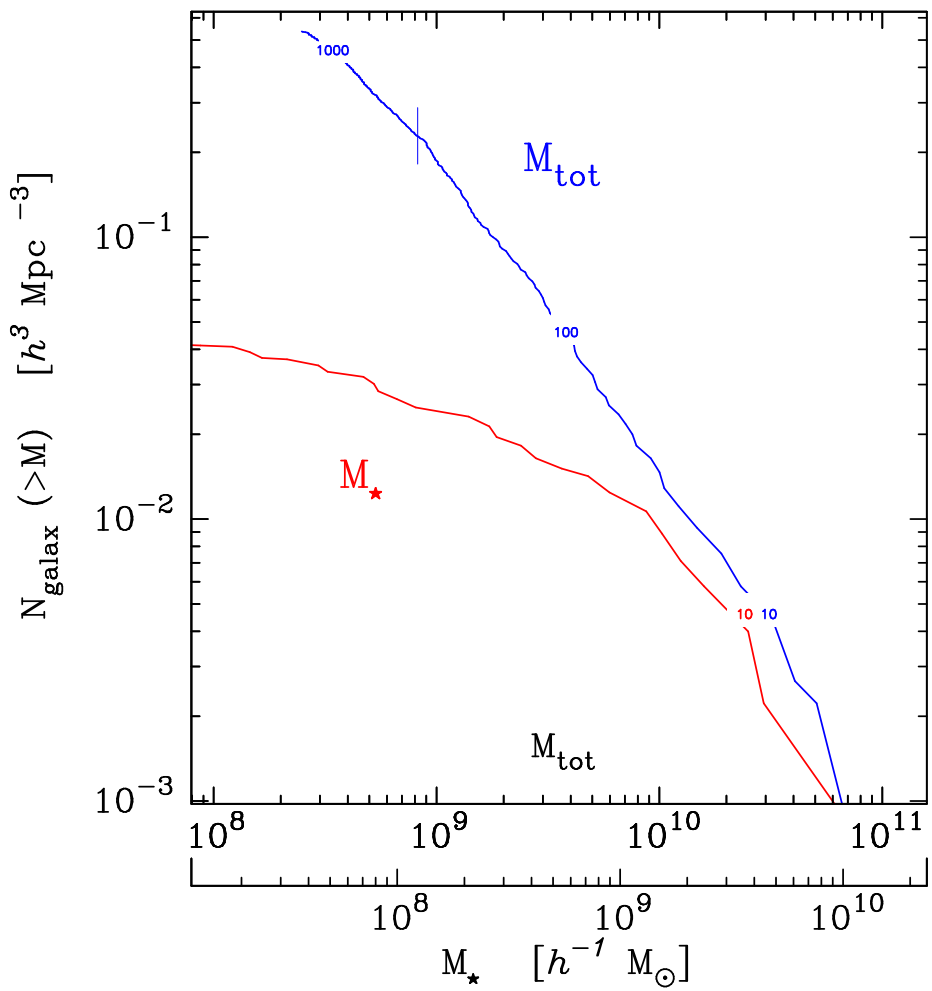
Stefan Gottlöber
sgottloeber@aip.de

Collaborators

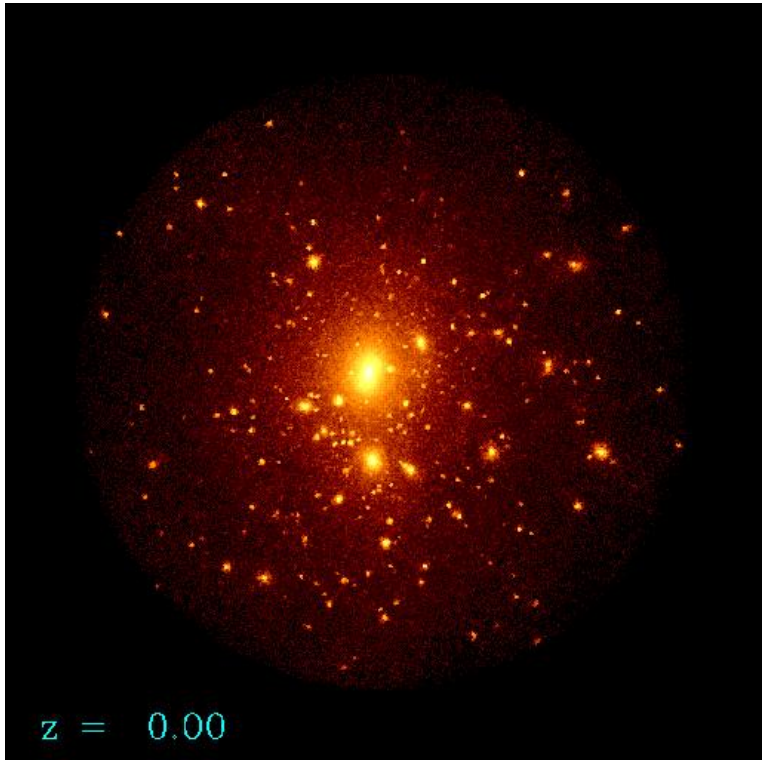
Andreas Faltenbacher (UCSC, Santa Cruz)
Anatoly Klypin (NMSU, Las Cruces)
Andrey Kravtsov (CfCP, U.Chicago)
Argyro Tasitsiomi (CfCP, U.Chicago)
Jan Mücket (AIP, Potsdam)
Matthias Hoeft (IU, Bremen)
Gustavo Yepes (UAM, Madrid)
Yago Ascasibar (Oxford)

Gustavo's talk on void galaxies





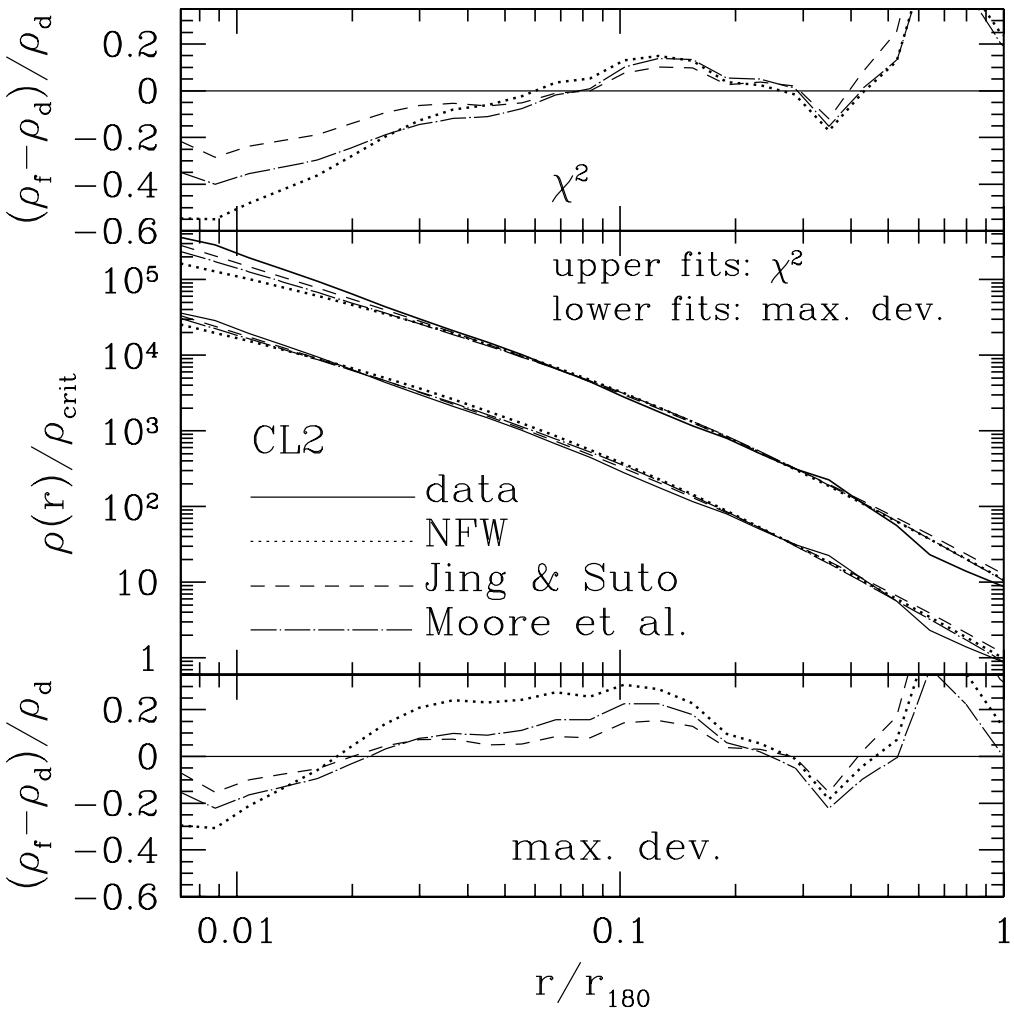
Galaxy clusters



simulation with 10 million particles
start: $z = 50$

Coma-Cluster (Abell 1656)
about 1000 (large) galaxies

Fitting density profiles



$$\frac{\rho}{\rho_0} = \frac{\delta_c}{x(1+x)^2} \qquad \text{NFW}$$

$$= \frac{\delta_c}{x^{3/2}(1+x^{3/2})} \qquad \text{M}$$

$$= \frac{\delta_c}{x^{3/2}(1+x)^{3/2}} \qquad \text{JS}$$

$$x = \frac{r}{r_s}$$

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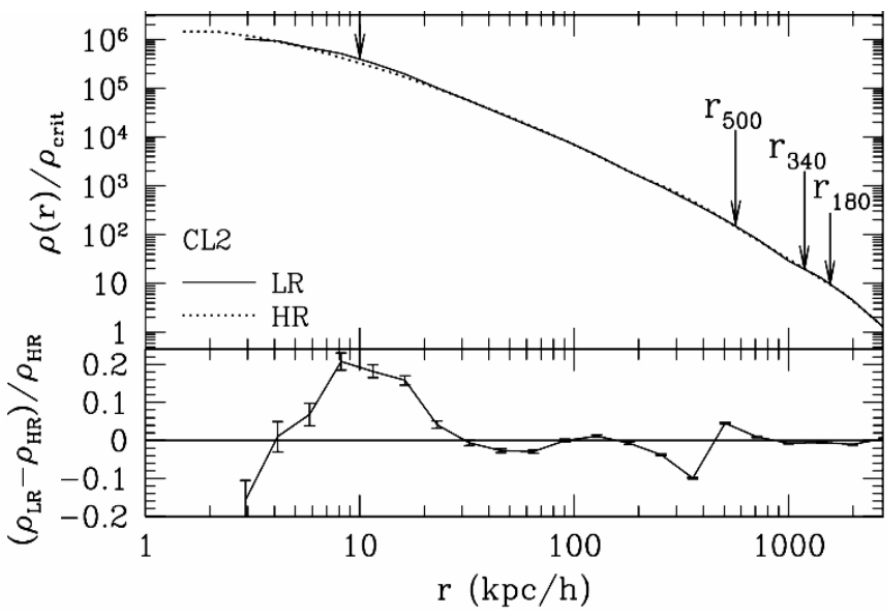
Measured cluster profiles



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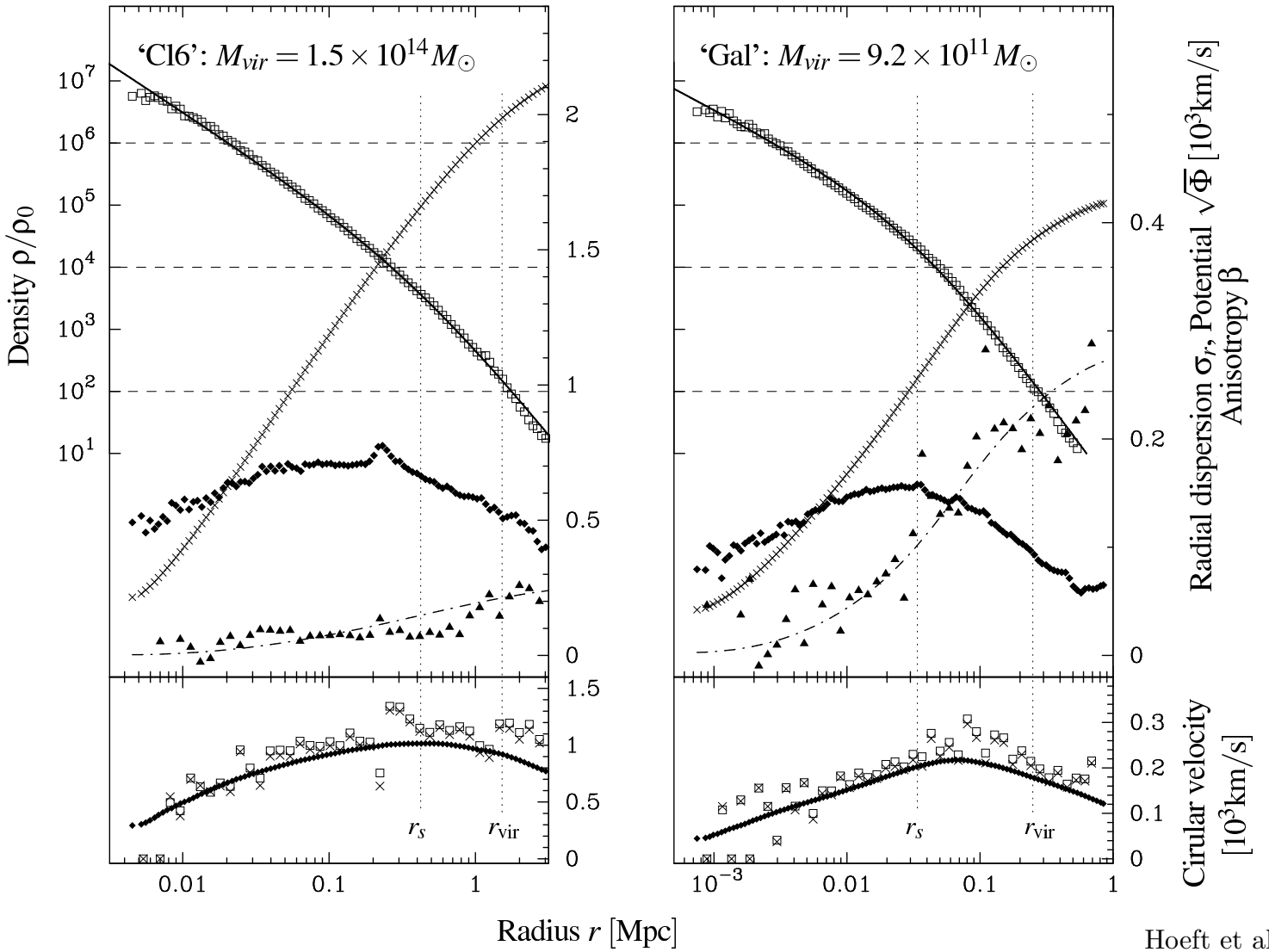
Density profiles of a cluster in low- (LR, 1.5 million particles) and high-resolution (HR, 8 million particles).

Table 1: Cluster density profiles

Halo	Best fit	slope at $0.03r_{180}$
CL1	M	-1.23 ± 0.19
CL2	JS	-1.67 ± 0.15
CL3	NFW	-1.35 ± 0.20
CL4	JS	-1.89 ± 0.20
CL5	M	-1.30 ± 0.20
CL6	JS	-1.83 ± 0.19
CL7	JS	-2.01 ± 0.22
CL8	M	-1.25 ± 0.22
CL9	M	-1.68 ± 0.22
CL10	M	-1.78 ± 0.28
CL11	NFW	-1.38 ± 0.31
CL12	M	-1.50 ± 0.24
CL13	JS	-1.36 ± 0.42
CL14	JS	-1.42 ± 0.30

evolution of profiles?



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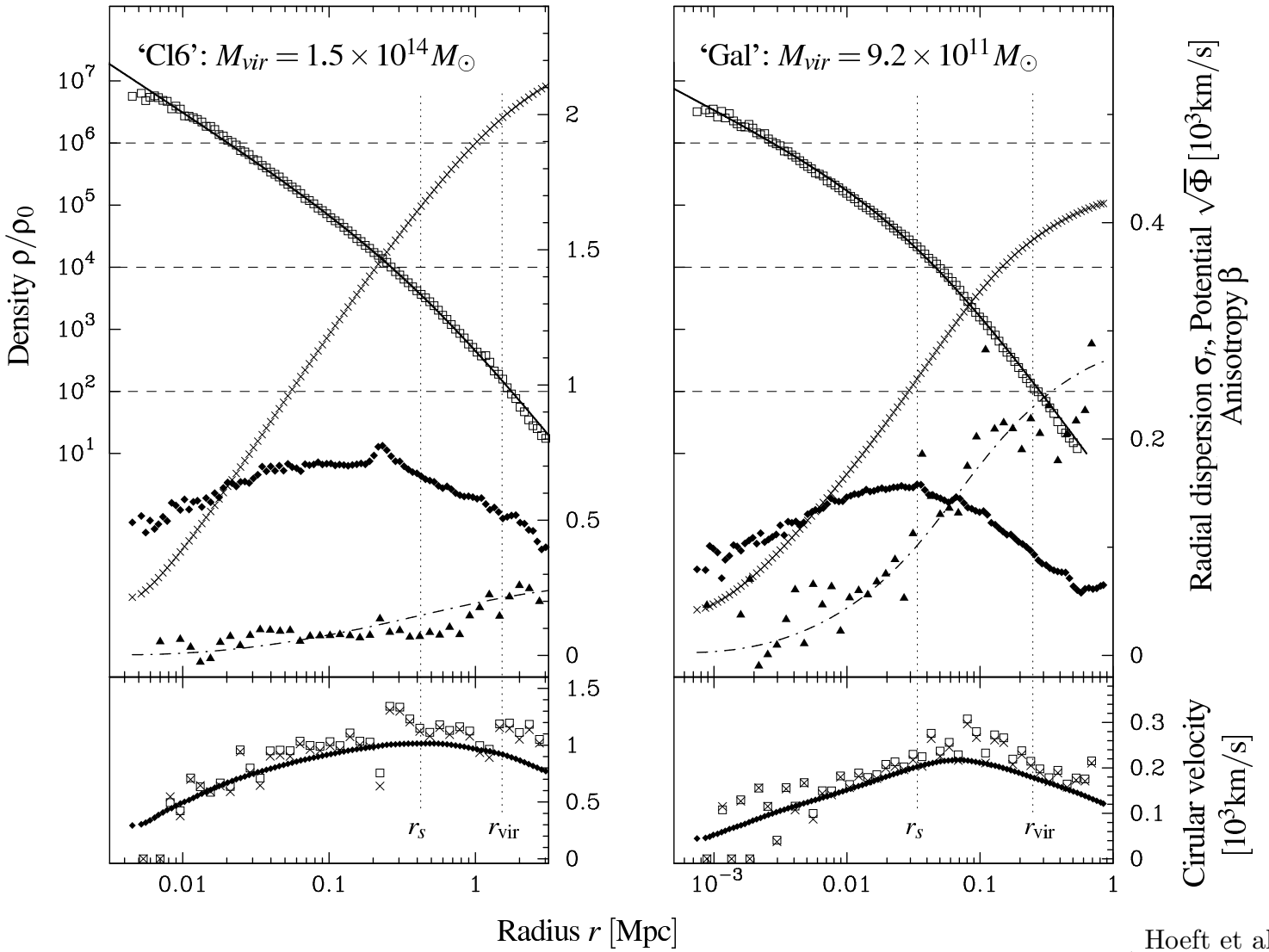
Upper panel: Density ρ/ρ_0 (open squares), potential $\sqrt{\Phi}$ (crosses), radial velocity dispersion σ_r (solid squares), anisotropy β (triangles).



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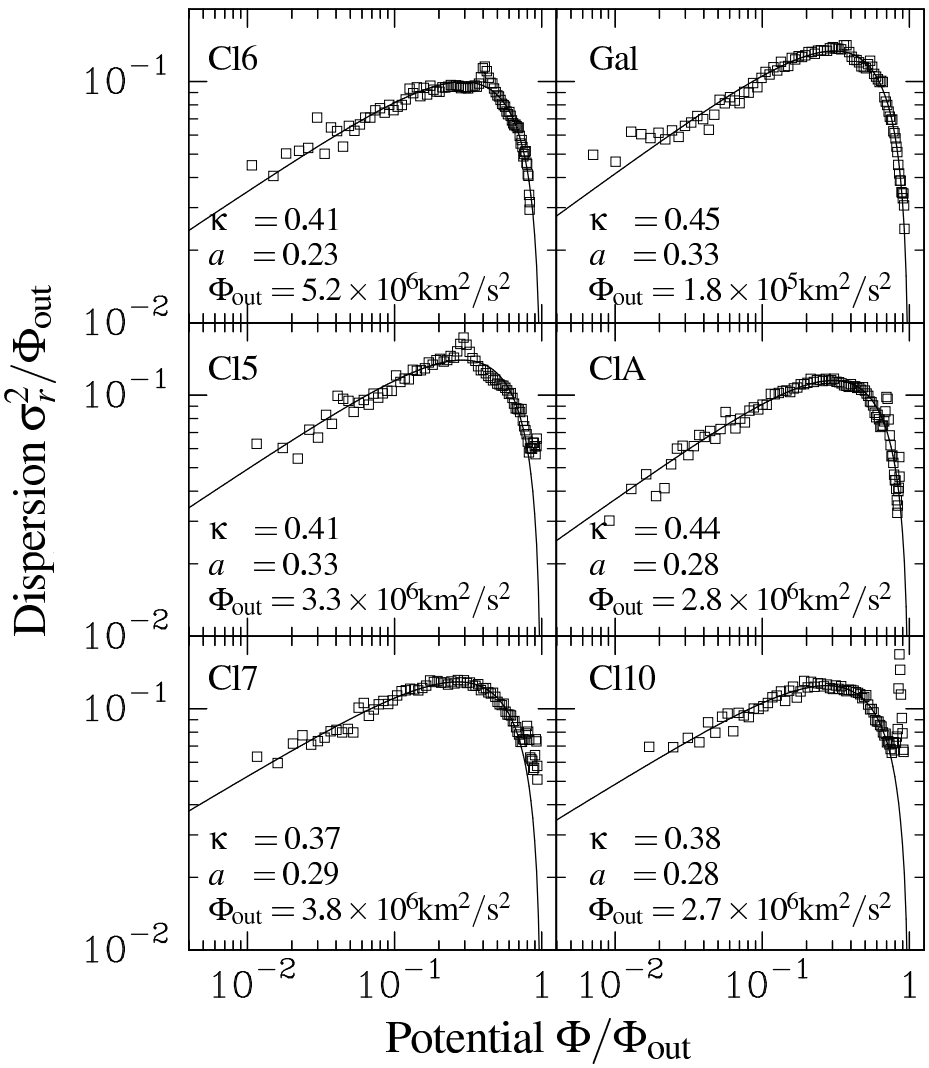
Lower panel: Circular velocity from Jeans equation (crosses; open squares assuming $\beta = 0$), circular velocity from simulation (solid squares).

$$v_c^2 = GM(r)/r = r\,\frac{d\Phi}{dr} = -\frac{r}{\rho}\frac{d(\rho\sigma_r^2)}{dr} - 2\,\beta\sigma_r^2$$



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Ansatz:

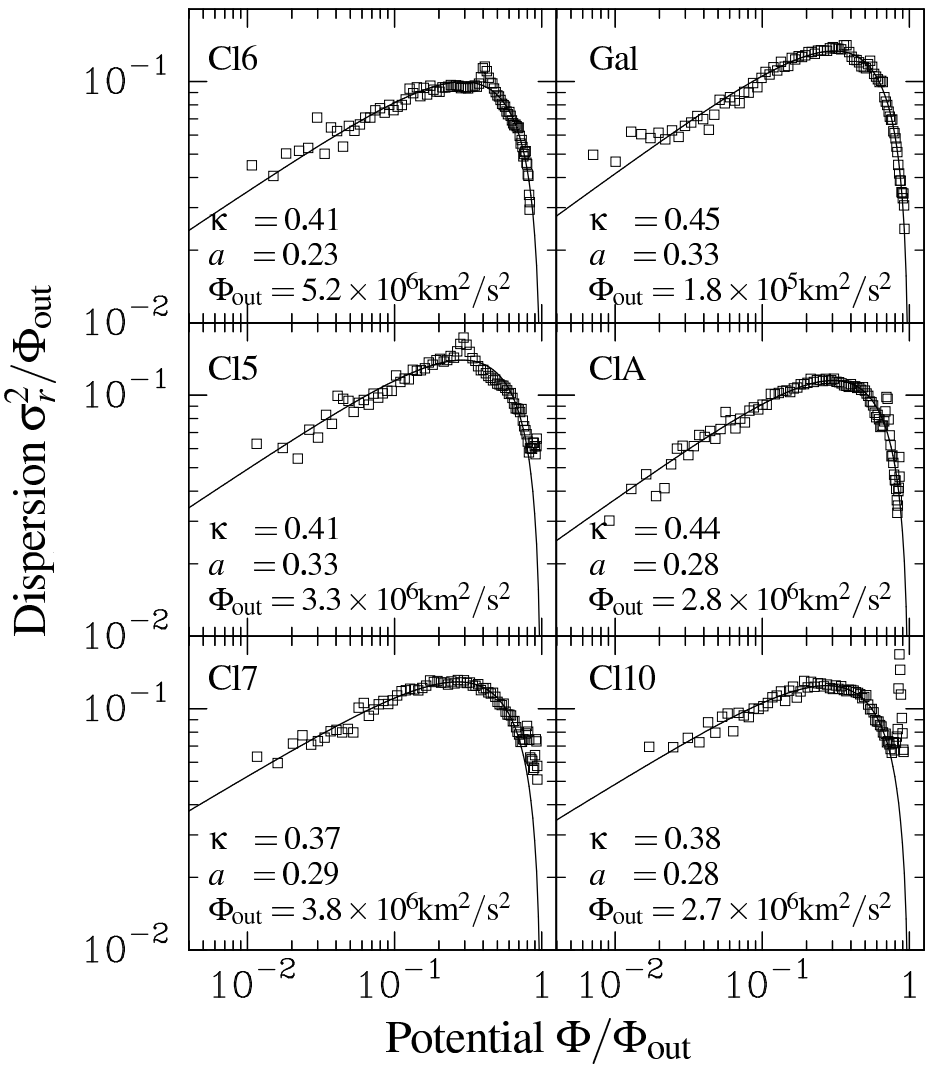
$$\frac{\sigma_r^2}{\Phi_{\rm out}} = a\left(\frac{\Phi}{\Phi_{\rm out}}\right)^{\kappa}\left(1-\frac{\Phi}{\Phi_{\rm out}}\right)$$

inserting into Jeans equation:

$$\rho(\Phi)\,|_{r\ll r_s} = \rho_0\,\left(\frac{\Phi}{\Phi_{\rm out}}\right)^{-\kappa}\exp\left(-\frac{(\Phi/\Phi_{\rm out})^{1-\kappa}}{a(1-\kappa)}\right)$$

inserting into Poisson equation:

$$\rho(r)\,|_{r\ll r_s} = \rho_0\,(r/r_0)^{-2\kappa/(1+\kappa)}$$



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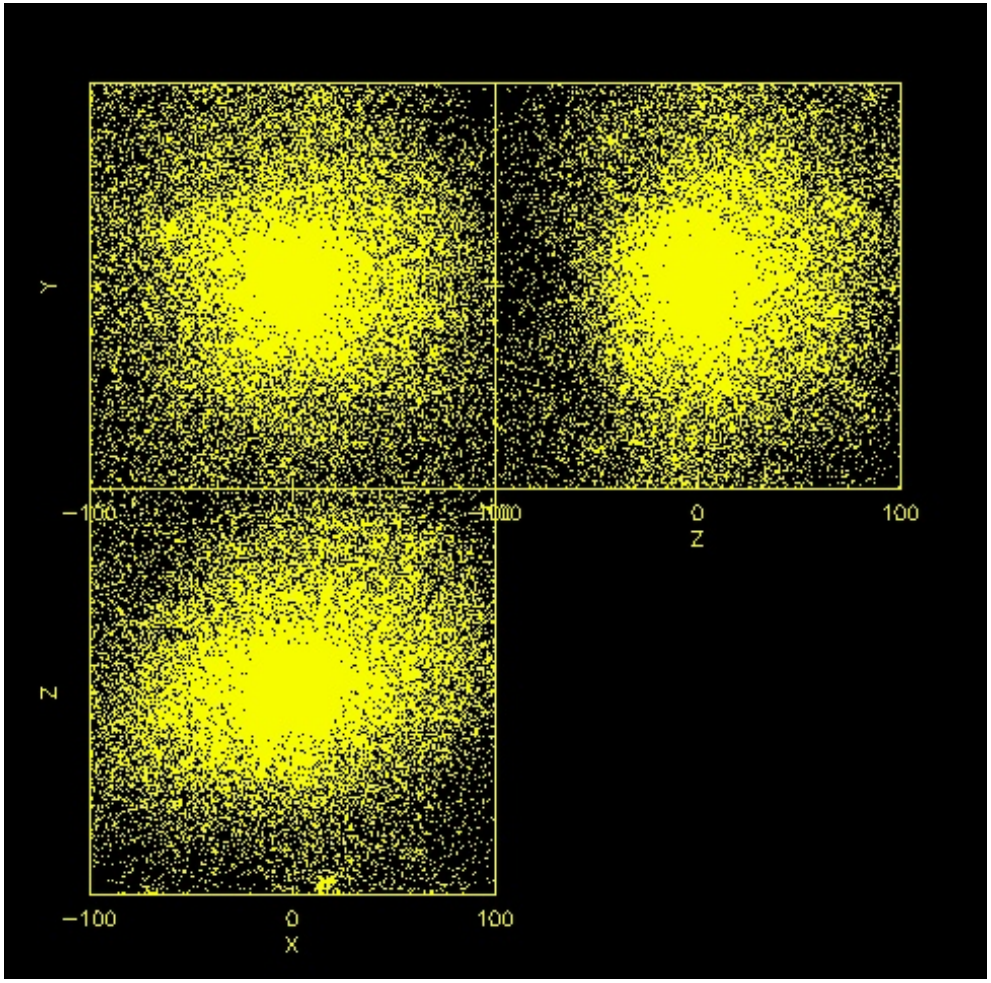
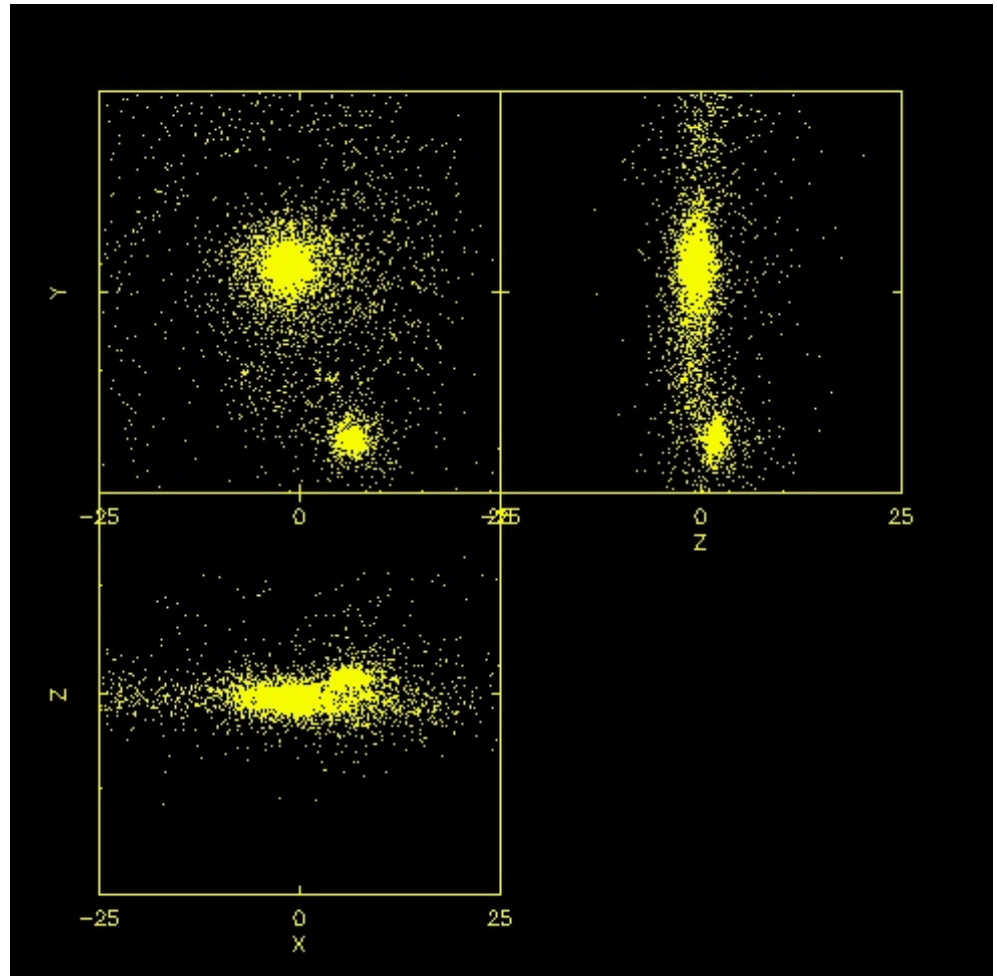
predicted inner density profile

$$n = -2\kappa/(1+\kappa)$$

$$\kappa = 0.41 \Rightarrow \quad n = -0.58$$

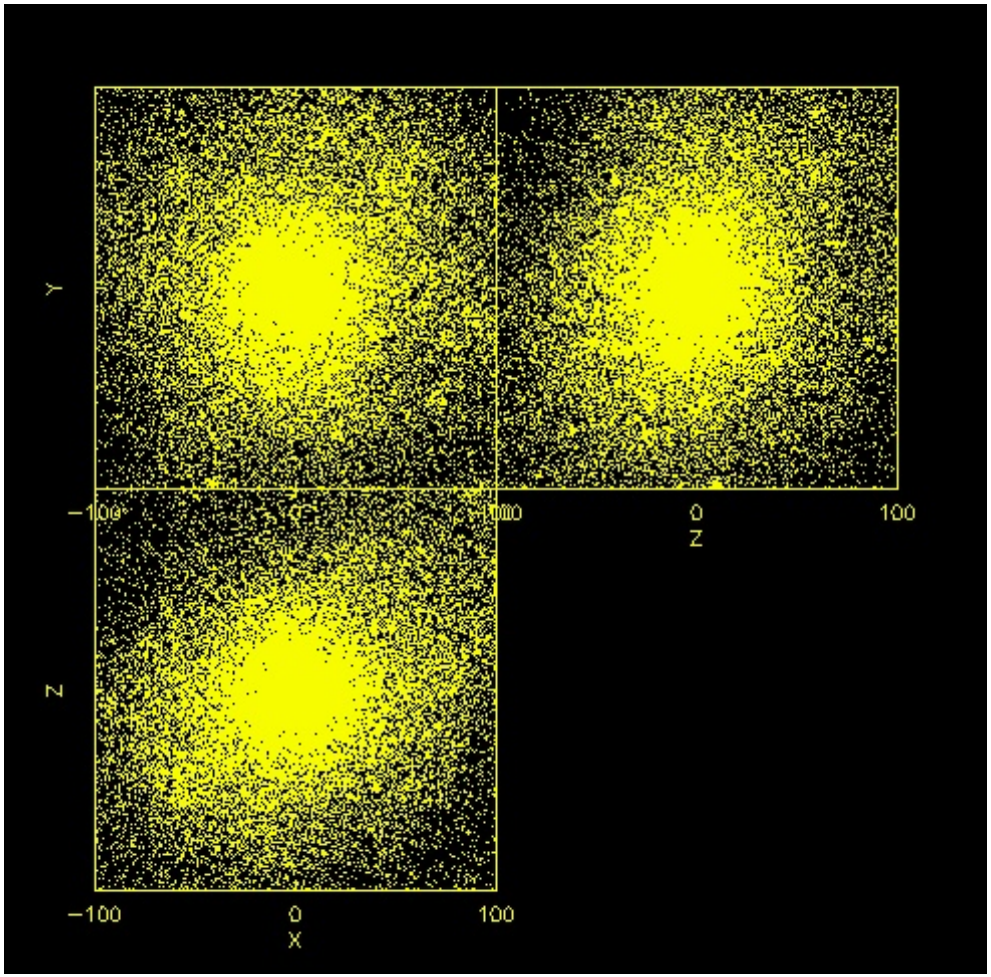
Outlook - disk formation

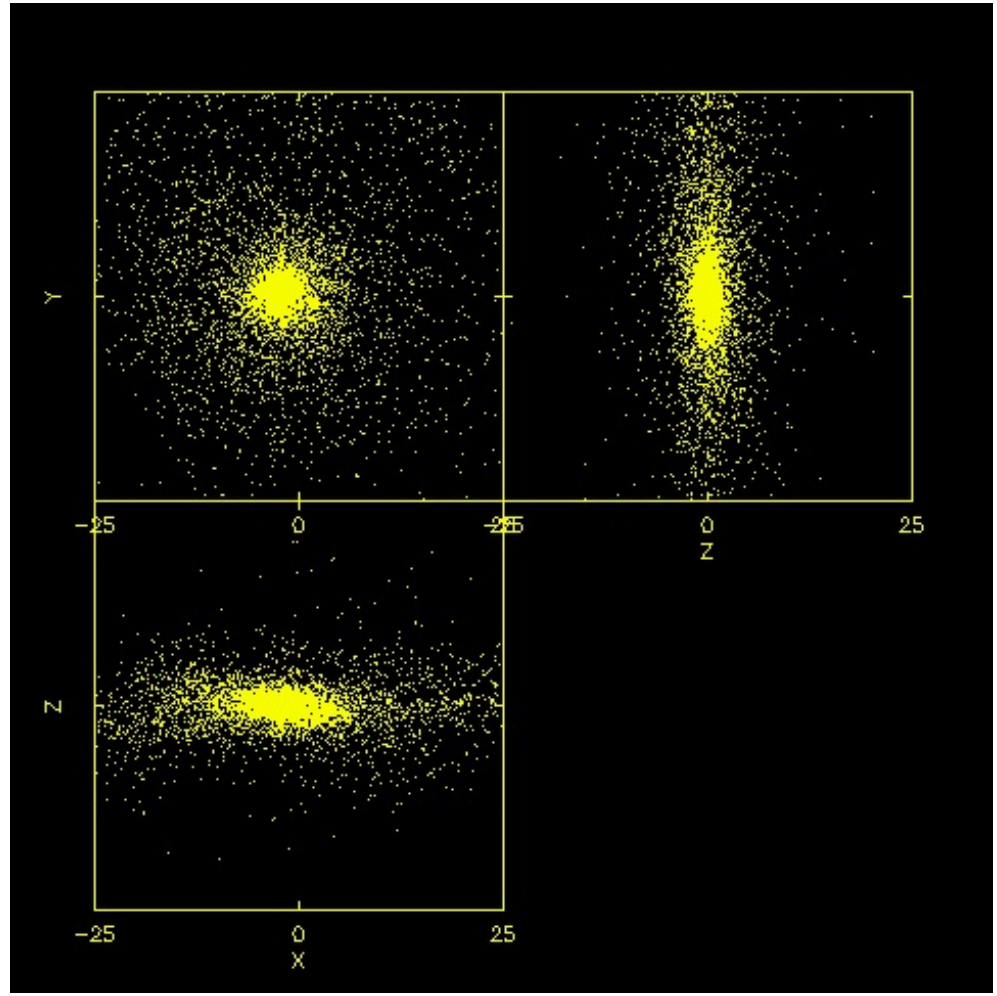




test simulation: redshift 1.5, $0.3 \times 10^{12} h^{-1} \mathrm{M}_{\odot}$, 70 000 particles

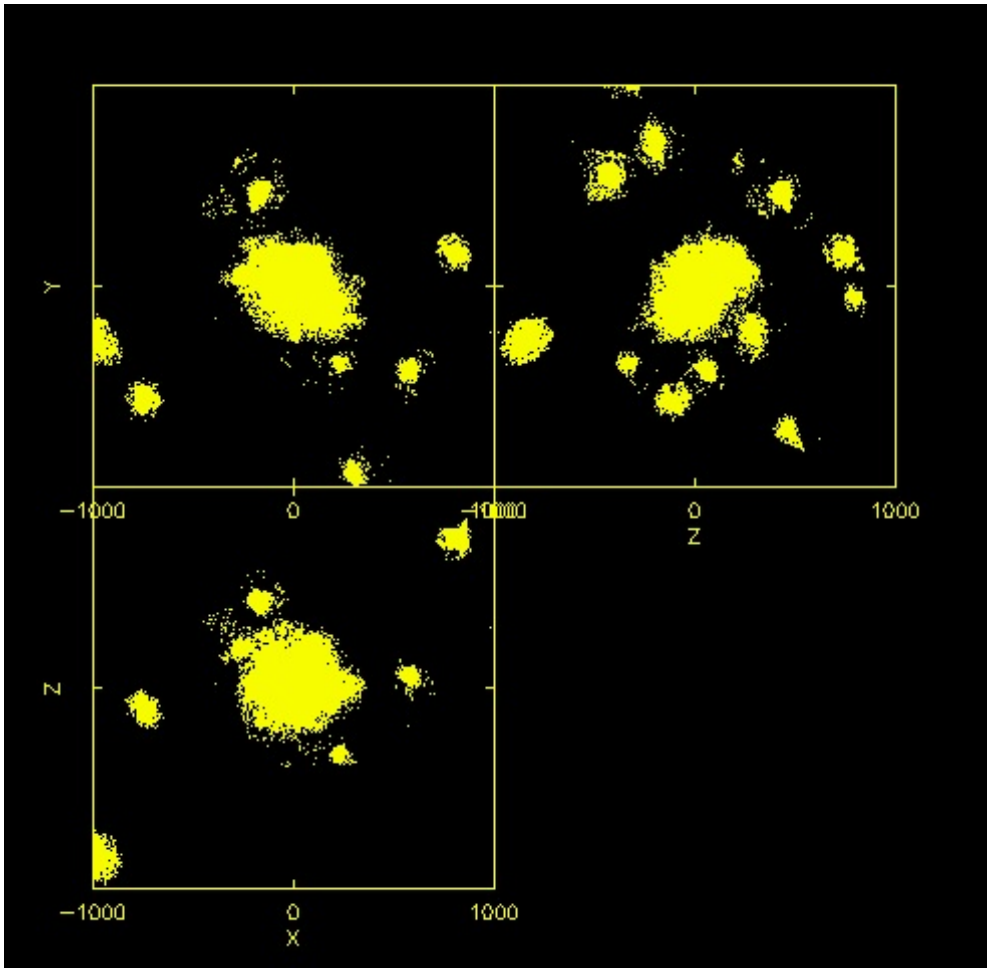
Outlook - disk formation

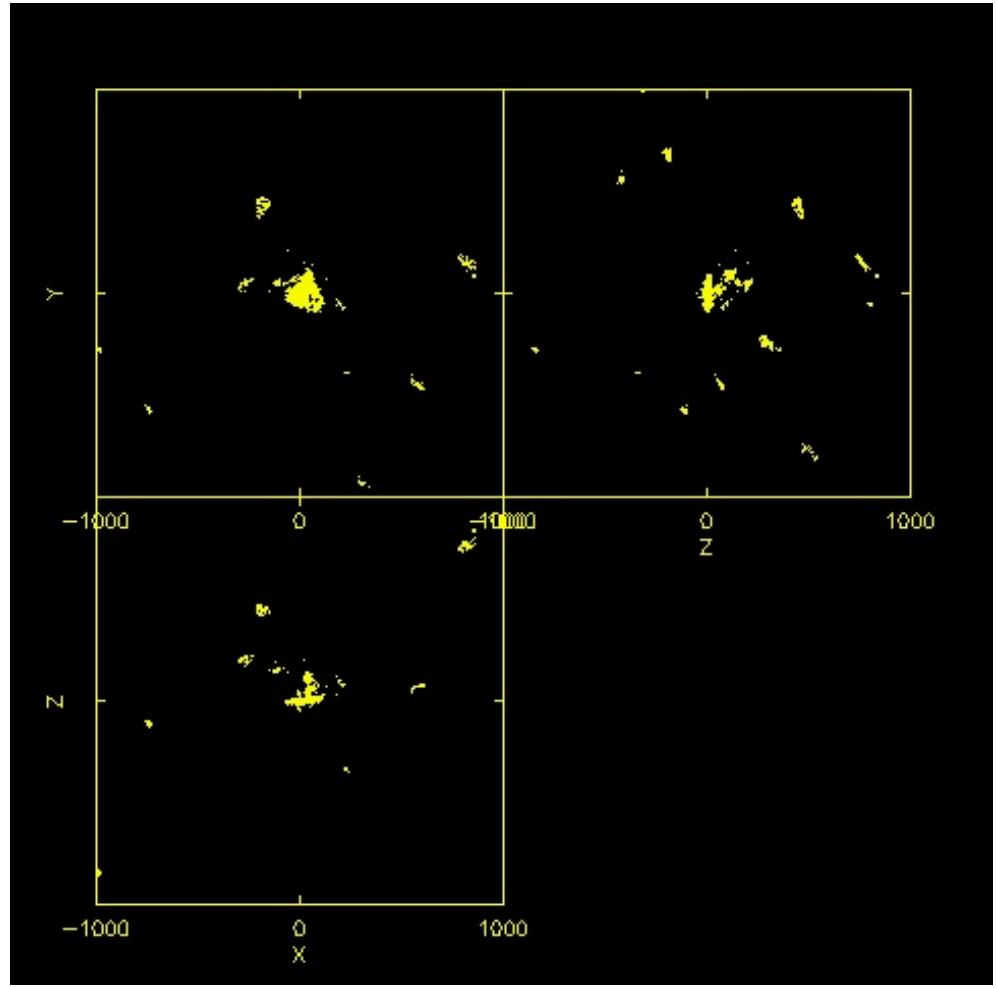




test simulation: redshift 1.3, $0.3 \times 10^{12} h^{-1} \mathrm{M}_{\odot}$, 70 000 particles

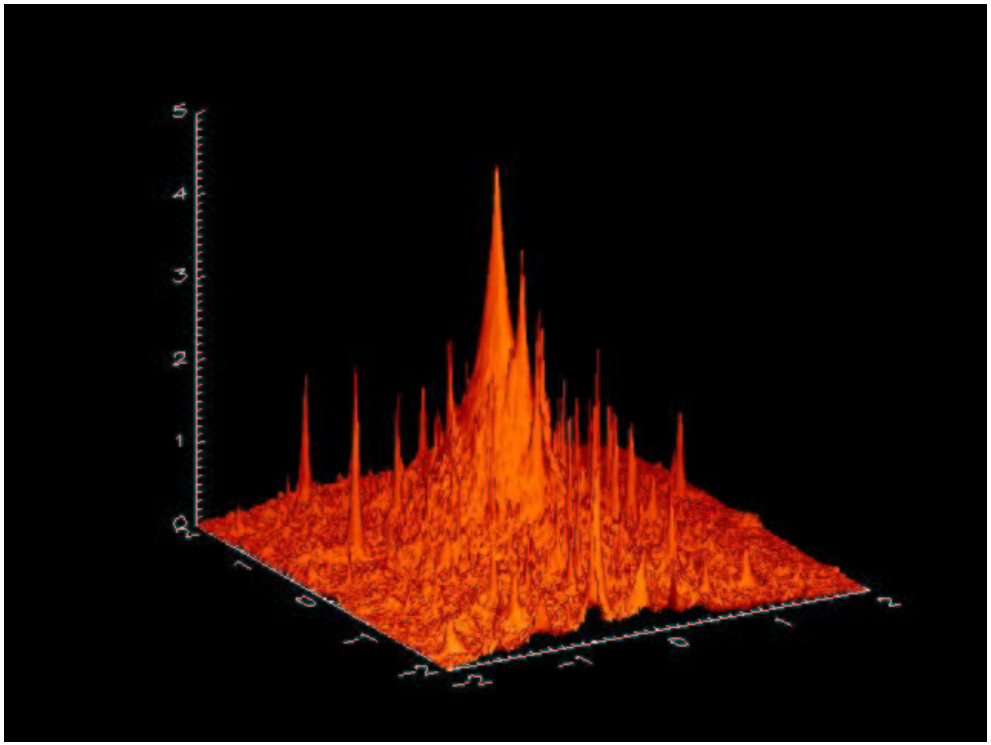
Outlook - disk formation

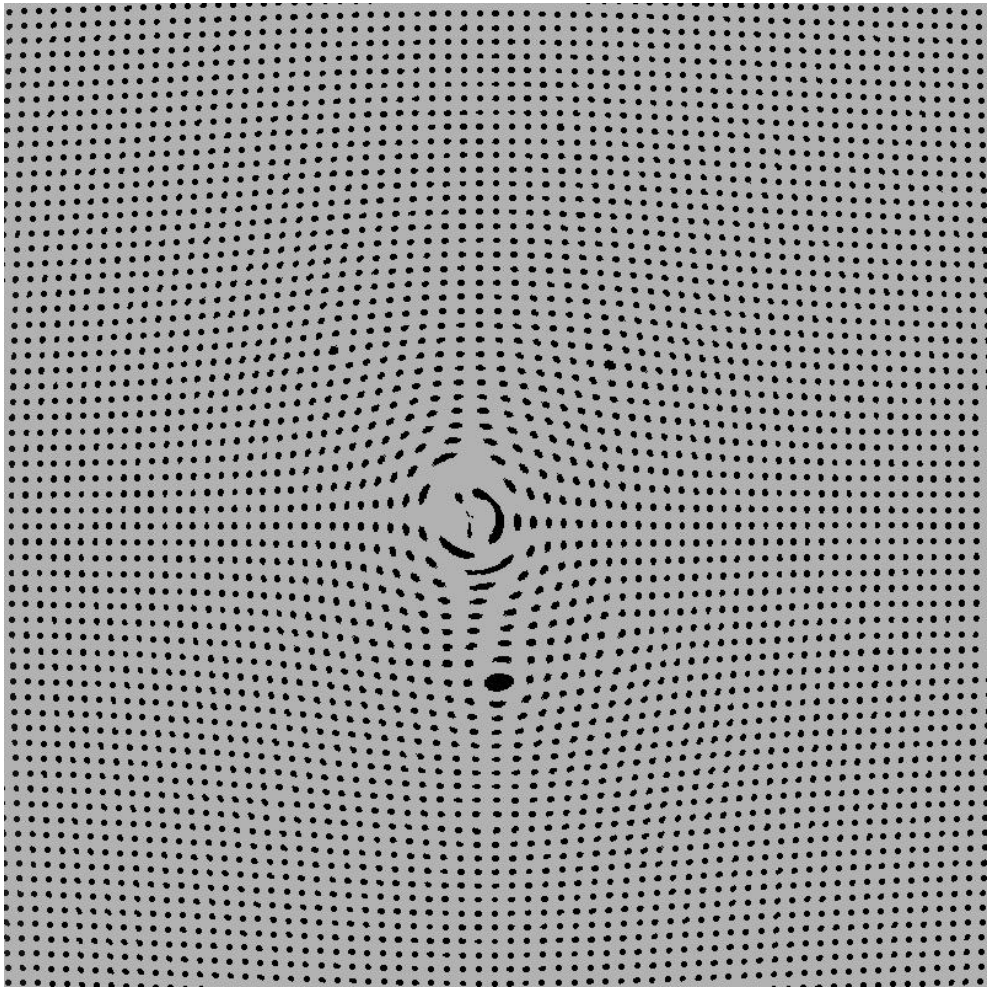




test simulation: redshift 1.3, zoom out

Outlook - measuring slopes





test: cluster and lensed images of a background source