



Fundamental Theory

- Global expansion history
- Initial power spectrum
- Linear growth history
- DE-DM-baryon interaction

Simulation

- Calculate nonlinear evolution
- Calibrate observational measures
- Estimate realistic uncertainties

Observation

- "Standard" rod versus z
- (Non)linear P(k) vs z
- Object abundance vs z
- Object structure vs z

Simulations in the Transregio

Precision calibration of observational measures of $d_A(z)$, $D_+(z)$, n(M, z)

Use of nonlinear dark halo structure to constrain the nature of DM and thus DE

Exploration of the consequences of DM/DE coupling for the formation of structure



C2

 $\mathbf{C1}$

Simulations in the Transregio

C1

Precision calibration of observational measures of $d_A(z)$, $D_+(z)$, n(M, z)



Halo abundance in the Millennium Simulation

Springel et al 2005



Statistical errors on abundance small for <u>given</u> cosmology and <u>given</u> mass definition

Current models need tuning to fit quantitative data



Complex physics and internal structure of clusters makes *precise* conversion of observables to mass difficult It is now possible to *simulate* the formation of large populations of galaxies in their proper ACDM context



Springel, Frenk & White 2006

Galaxy autocorrelation function

Springel et al 2005



For such a large simulation the purely statistical error bars are negligible on ξ even for the galaxies

Clustering *does* depend on galaxy formation model



Baryon wiggles in the galaxy distribution

Springel et al 2005

Power spectra from the Millennium run divided by a baryon-free Λ CDM spectrum

Nonlinear effects distort the mass power spectrum and the galaxy power spectrum in *different* ways

Characterizing the central structure of halos (C2)



DM halos have rich structure

which grows by merging,

depends on DM nature,

doesn't fit predictions of LCDM

and affects signal in DM detectors

-0.10 -0.05

0.15

-0.05

0.00





Interacting Dark Matter / Dark Energy (C3)



Coupling between DM and DE can modify *nonlinear* dynamics -- differing gravitational acceleration on DM and baryons -- effective DM particle mass varies with time First models studied made problems with ∧CDM worse A systematic study of possible models and their observable consequences is needed