Galaxy-galaxy lensing+clustering, environmental dependence, and cosmology

Ben Wibking, David Weinberg
CCAPP HOD Workshop
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Modeling methodology

- Fully numerical N-body+HOD+(environmental dependence) predictions for galaxy-mass cross-correlation, galaxy autocorrelation
- Run ~dozens of simulations with varying cosmological parameters
- Construct an ‘emulator’ through local finite difference interpolation, global spline fit, Gaussian Processes… (other ideas?)

Modeling methodology

- (Eventually) using full Abacus N-body simulation suite across range of cosmologies (thanks to Daniel Eisenstein et al.)
  - Using Fast Multipole Method (invented in ‘80s, but never applied to cosmology for unknown reasons)
  - *O(N)*
  - Strictly conserves (linear) momentum (treecodes do not do this)
  - (We think) this runs very fast (~millions of particles integrated per timestep per compute node)
- For now, small volume (180.7 Mpc h^{-1}, 256^3) GADGET-2 simulation

Modeling methodology

- But we don’t want to build an emulator unless we know that the constraints might actually be competitive!
- Even though ‘we are all Bayesians now,’ we have to use a tool from the frequentist toolbox

The Magic of the Fisher Matrix

- Fisher matrix: the inverse of the covariances *of the parameters you wish to constrain*

$$[F]^{-1} = [C] = \begin{bmatrix} \sigma_x^2 & \sigma_{xy} \\ \sigma_{xy} & \sigma_y^2 \end{bmatrix}$$

  - *(without knowing what the actual best fit parameters are)*

Math from arXiv:0906.4123

The Magic of the Fisher Matrix

- Directly yields estimates for confidence ellipses
- Area of ellipse is often considered to be the Figure of Merit for evaluating dark energy experiments (DETF)

$$a^2 = \frac{\sigma_x^2 + \sigma_y^2}{2} + \sqrt{\frac{(\sigma_x^2 - \sigma_y^2)^2}{4} + \sigma_{xy}^2}$$

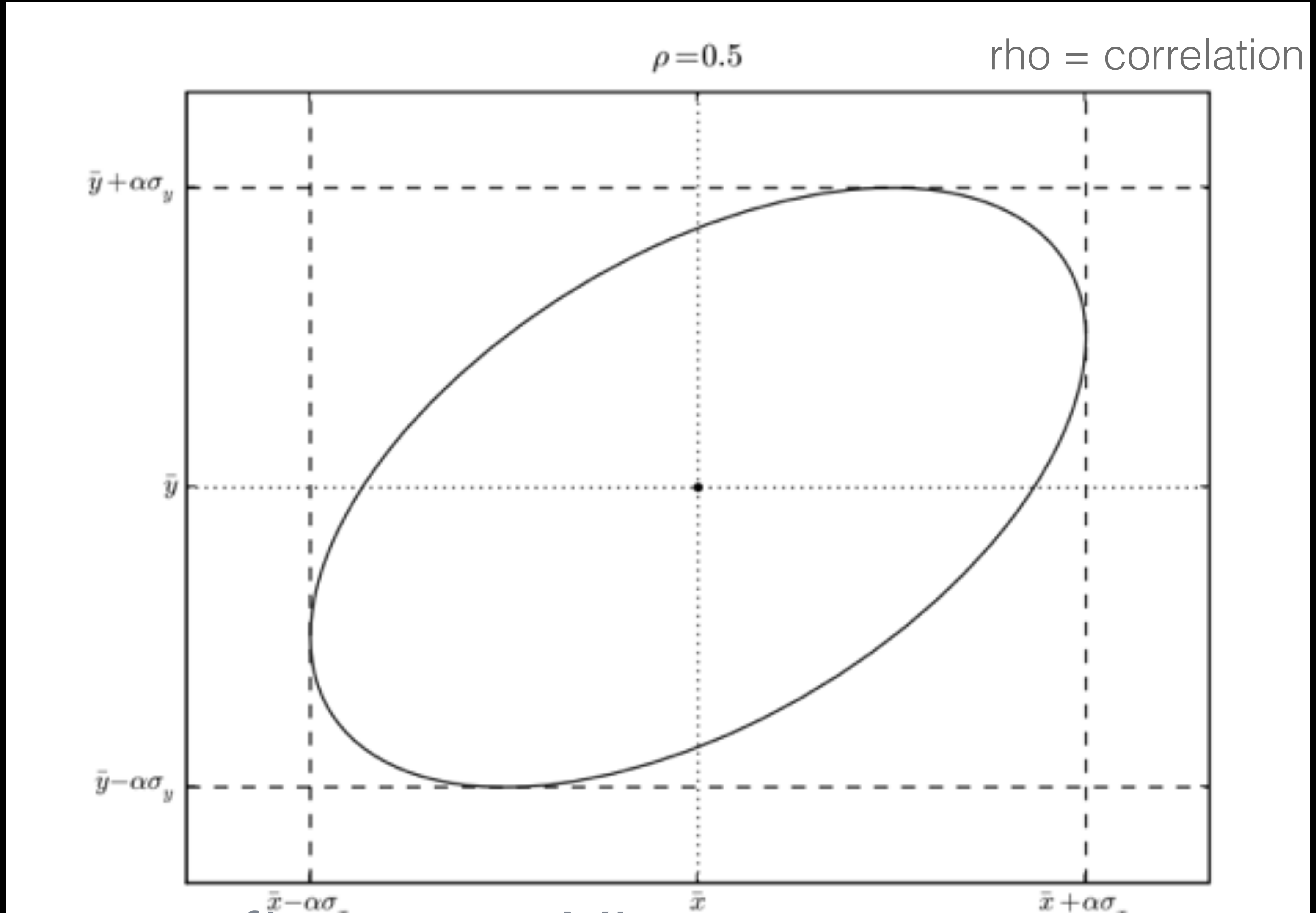
$$b^2 = \frac{\sigma_x^2 + \sigma_y^2}{2} - \sqrt{\frac{(\sigma_x^2 - \sigma_y^2)^2}{4} + \sigma_{xy}^2}$$

$$\tan 2\theta = \frac{2\sigma_{xy}}{\sigma_x^2 - \sigma_y^2}$$

Math from arXiv:0906.4123

The Magic of the Fisher Matrix

- Variances are *automatically* marginalized over changes in the other parameters



rho = correlation coefficient

figure: arXiv:0906.4123

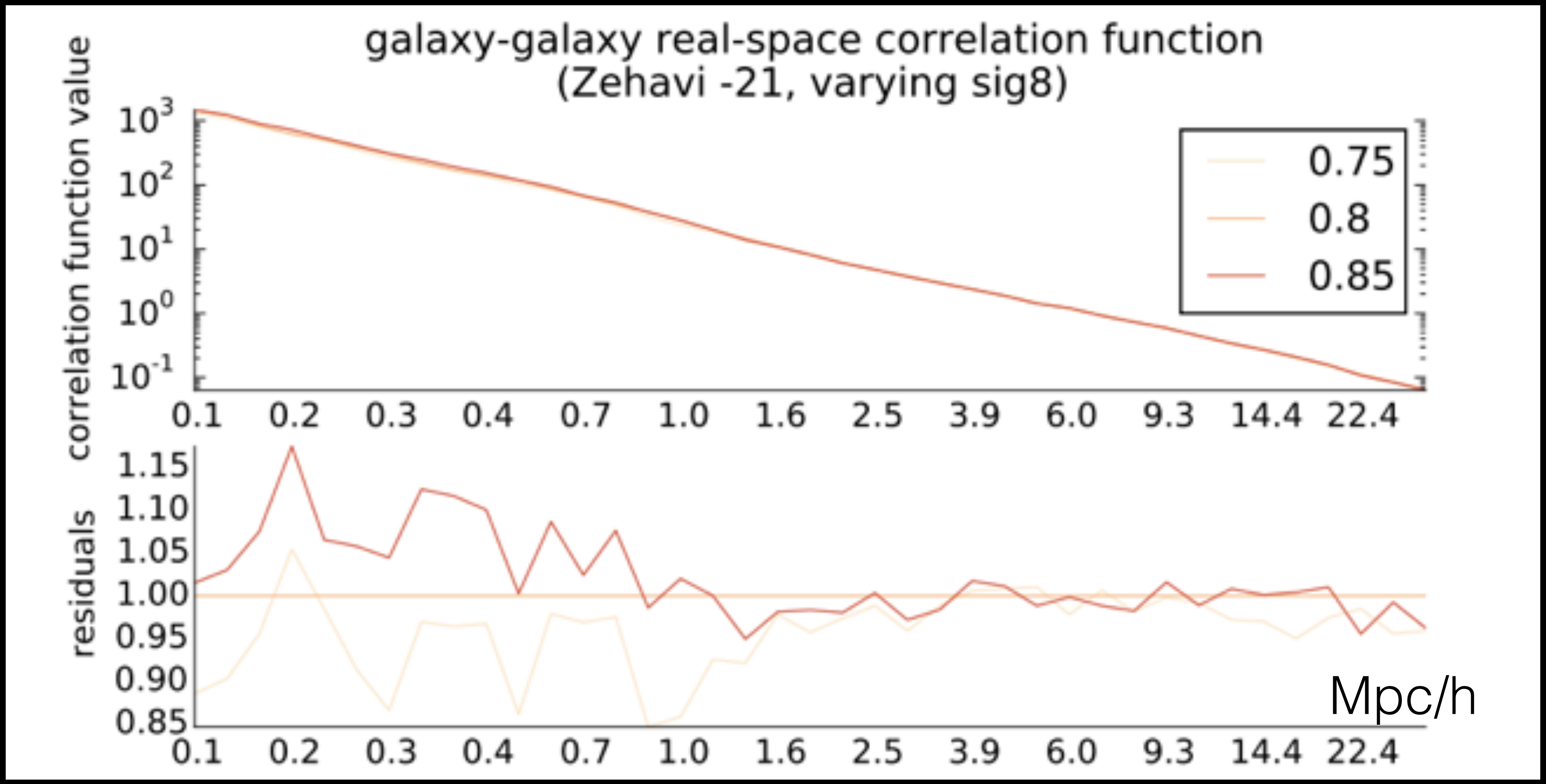
The Magic of the Fisher Matrix

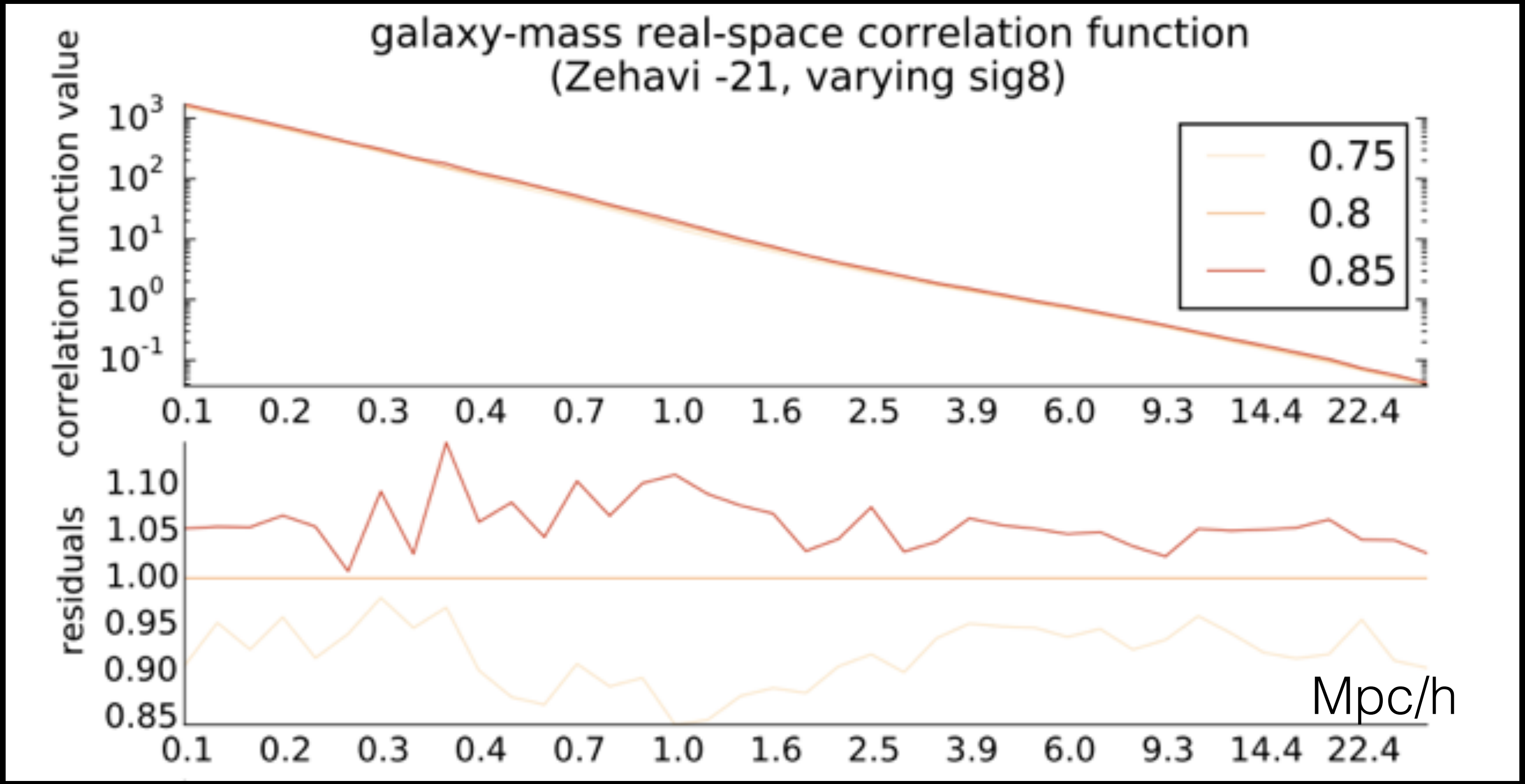
$$[F] = \frac{1}{2}\begin{bmatrix} \frac{\partial^2}{\partial x^2} & \frac{\partial^2}{\partial x \partial y} \\ \frac{\partial^2}{\partial x \partial y} & \frac{\partial^2}{\partial y^2} \end{bmatrix} \chi^2$$

- We must compute numerical derivatives *around a reasonable fiducial model* from our N-body +HOD predictions

- Compute chi-sq using a 'best guess' covariance matrix for the observables

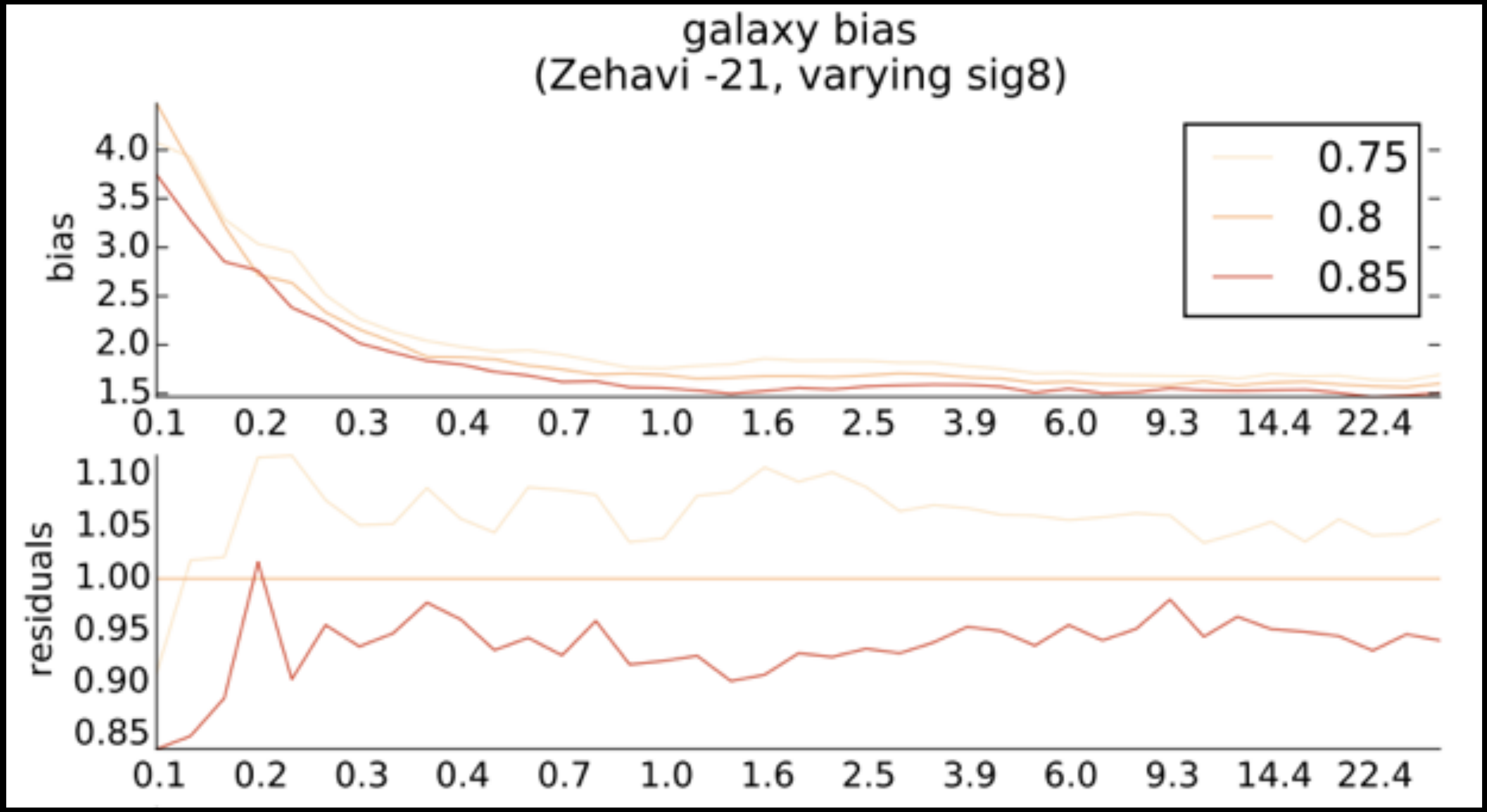
σ_8

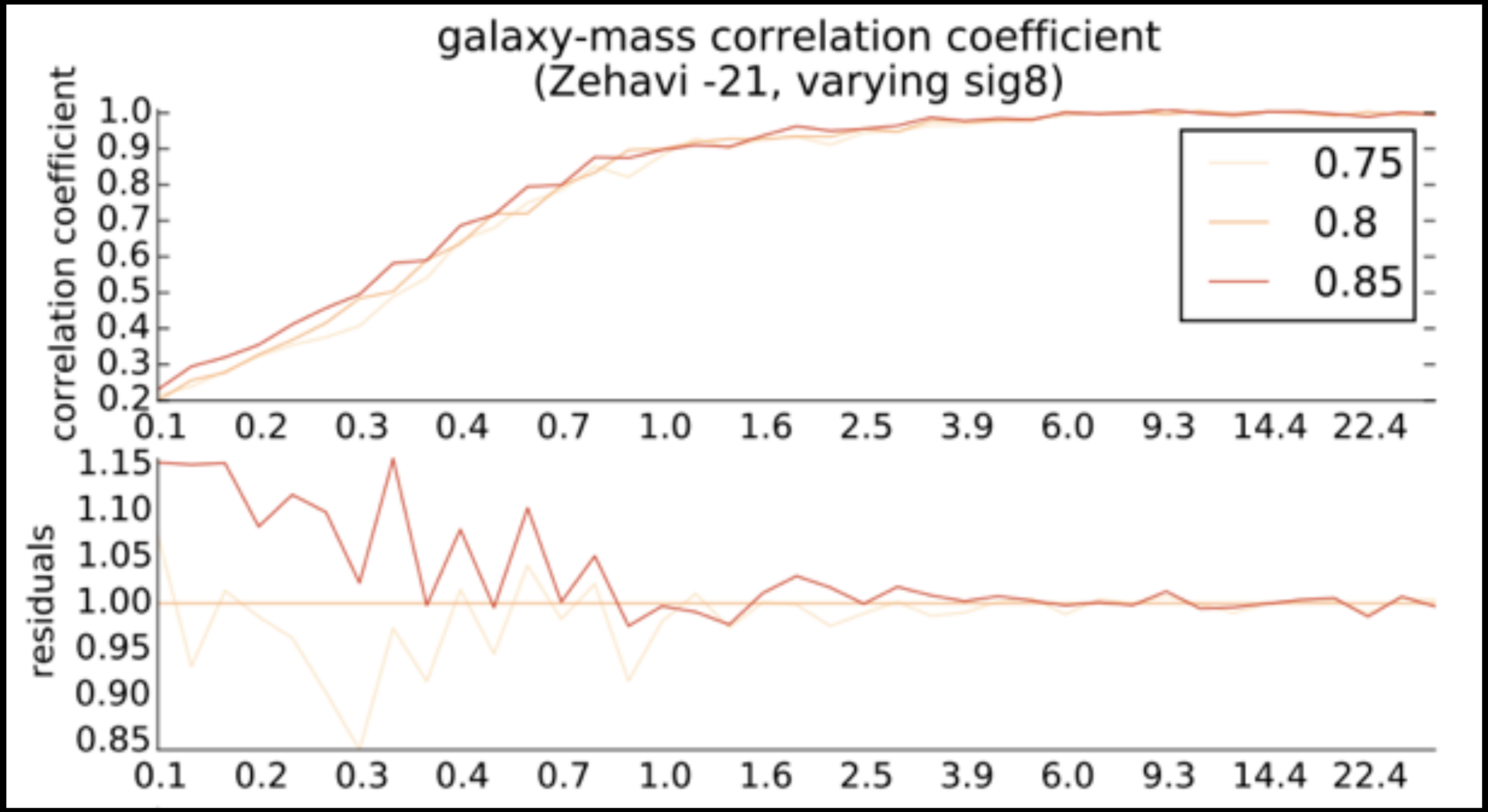




- Fiducial values from Zehavi et al. 2011

σ_8





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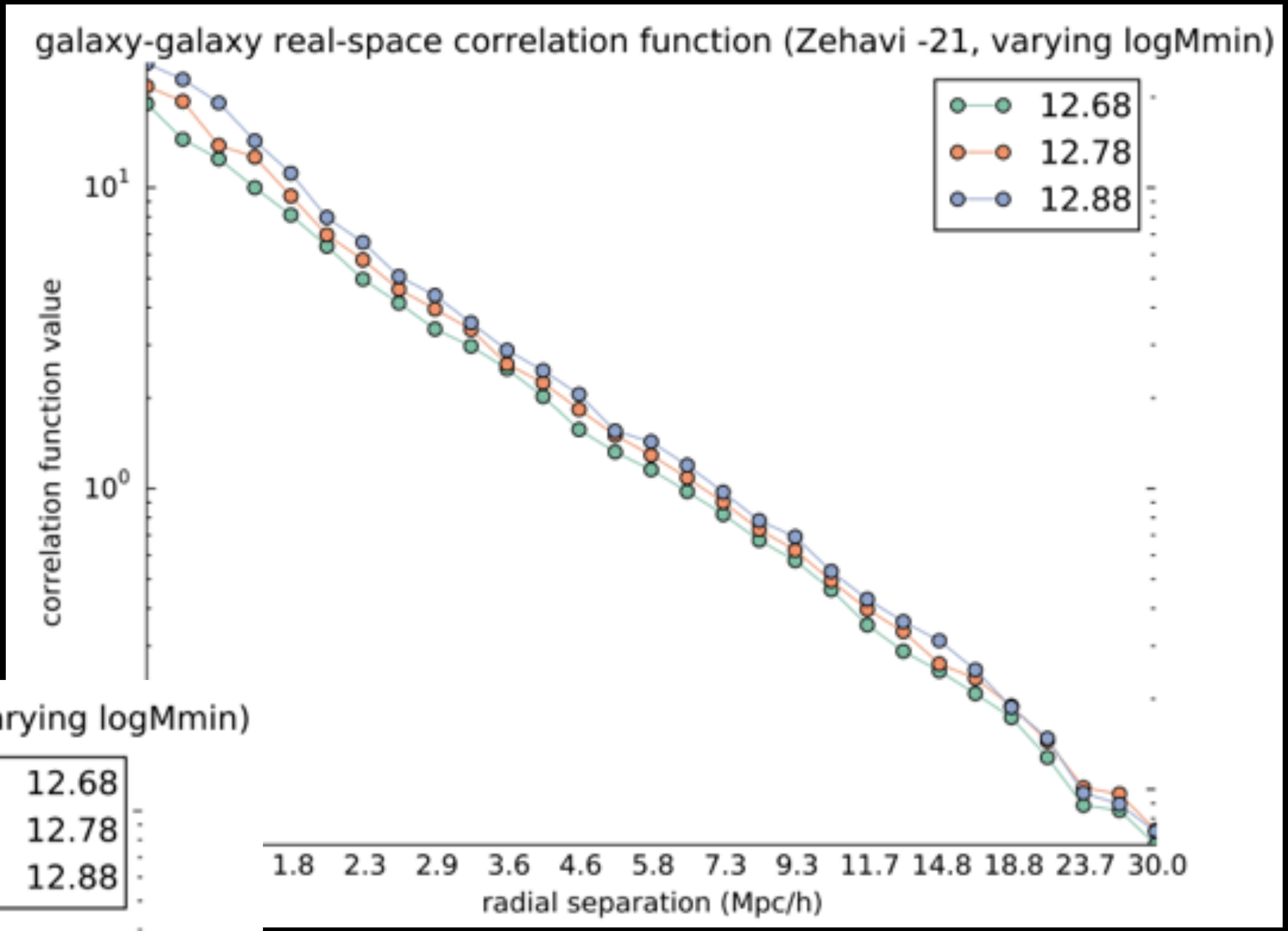
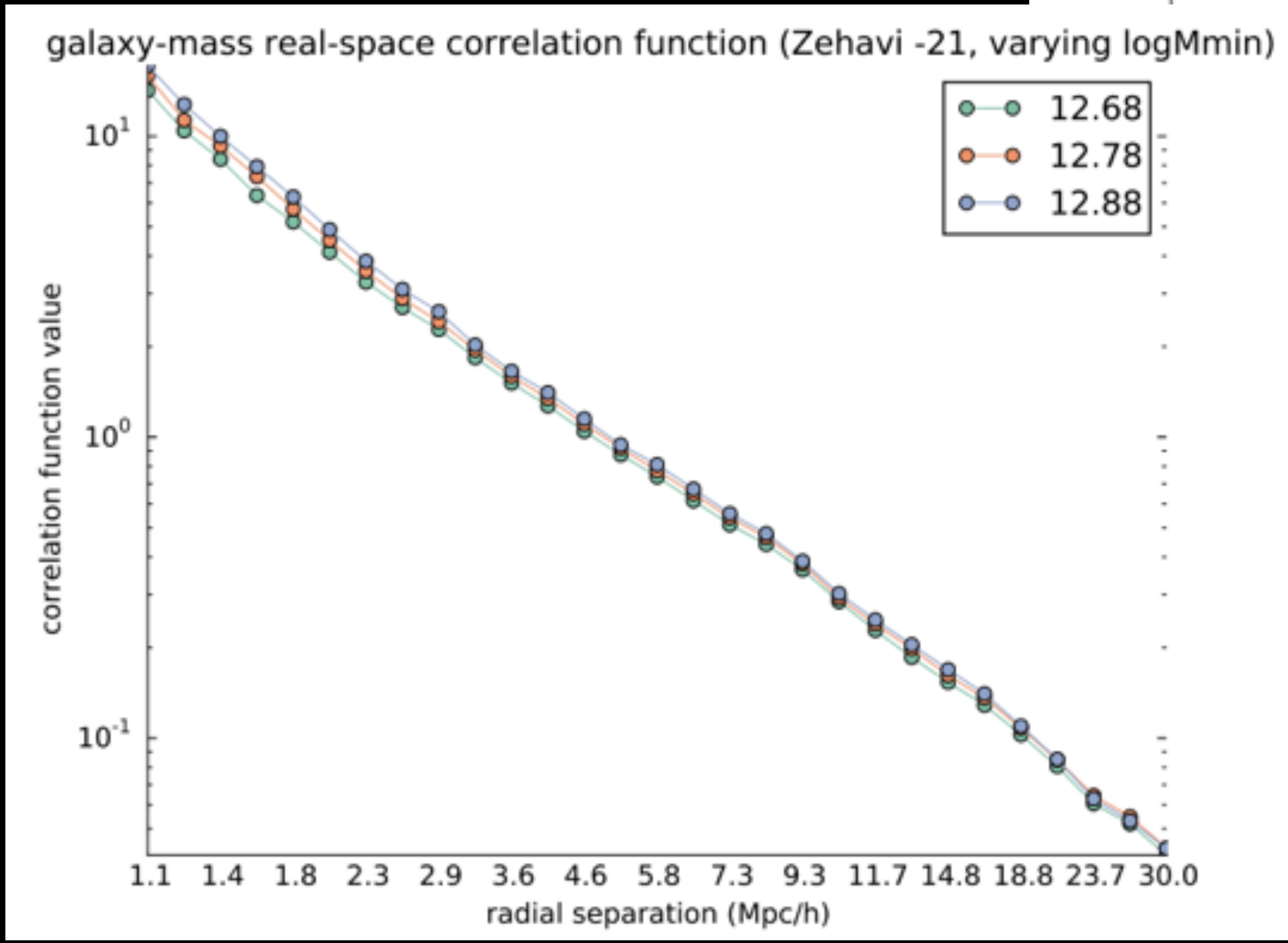
M_{min}





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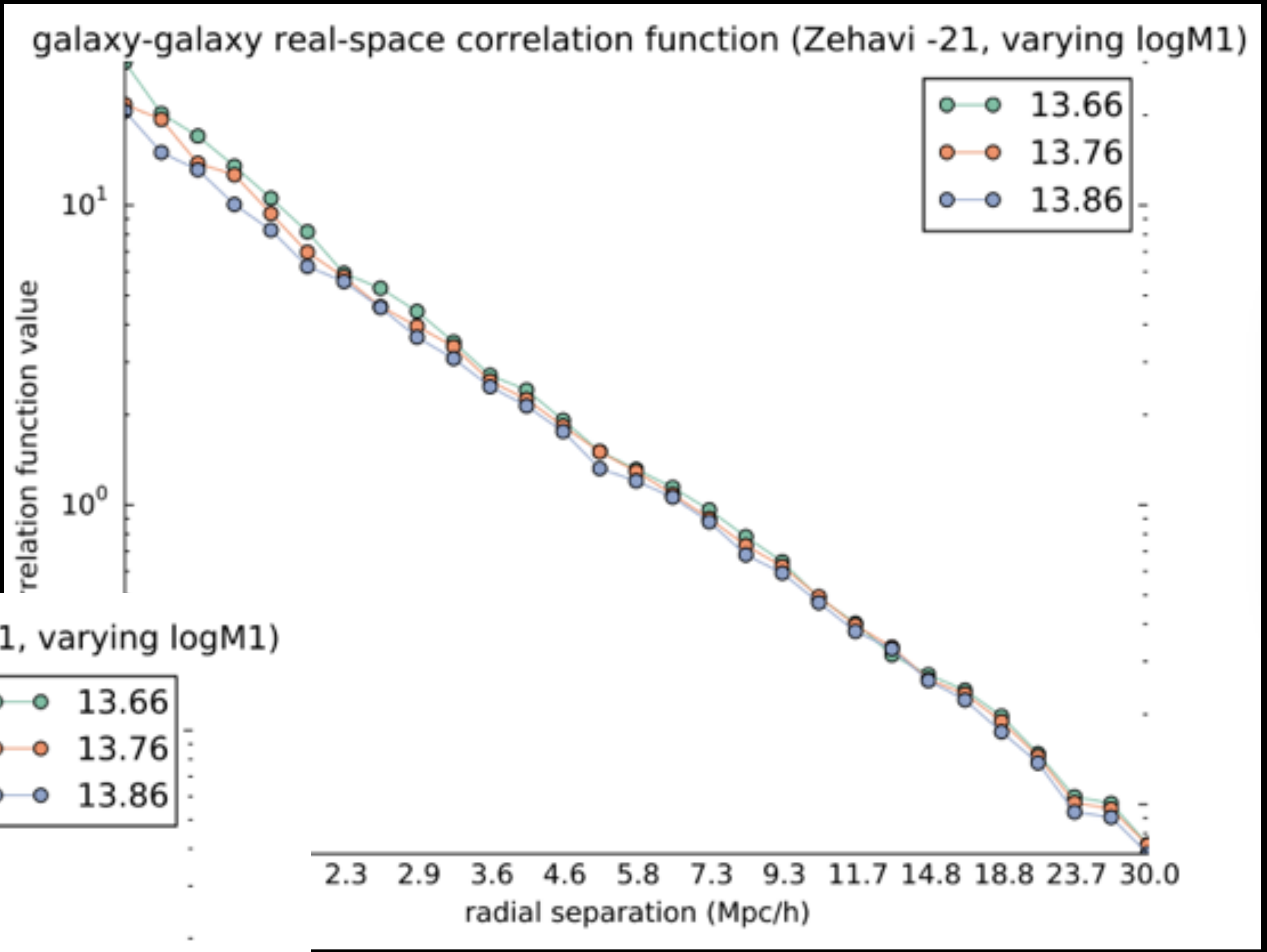
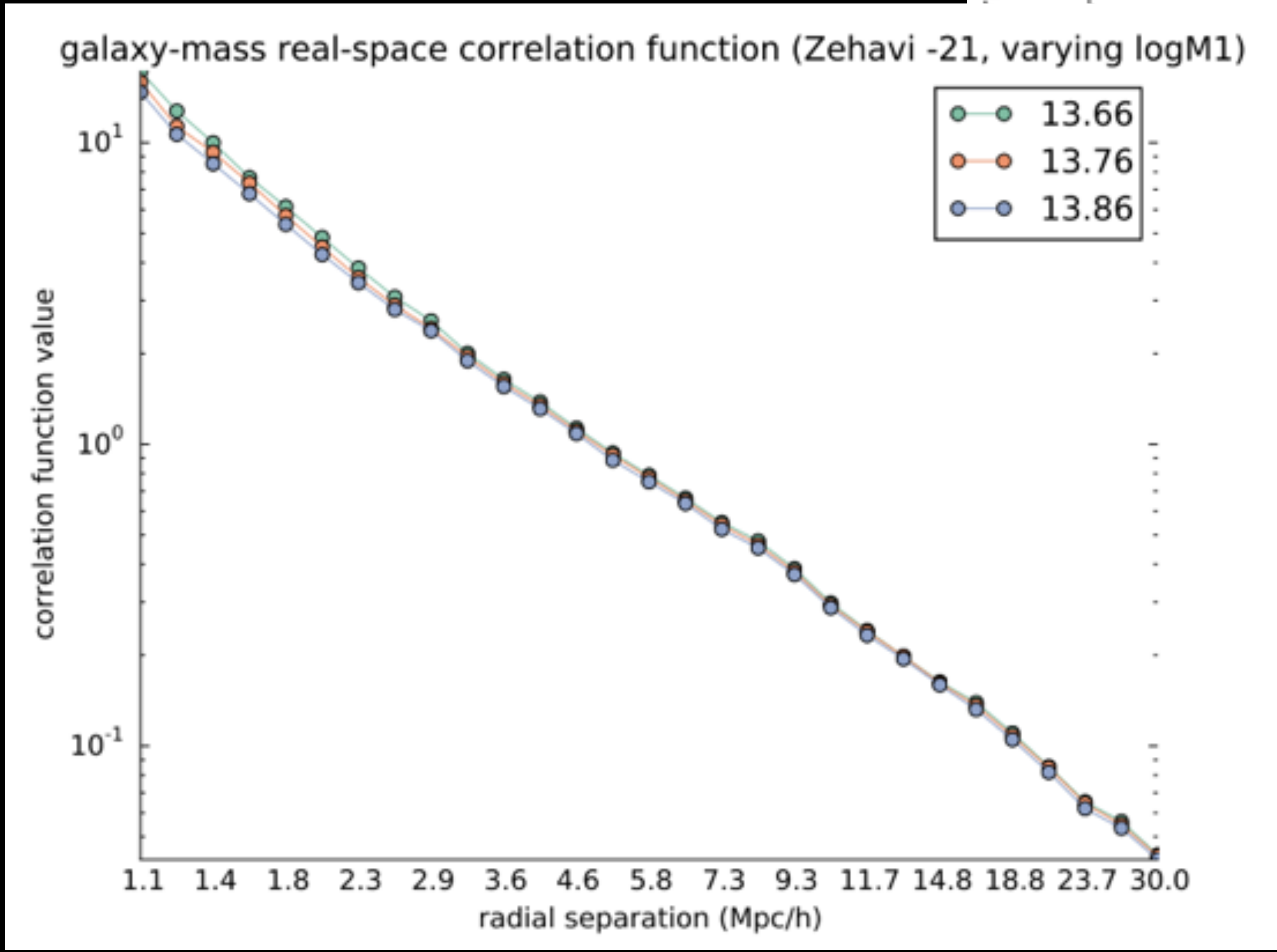
M_1





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Questions