Young fogeys and old turks: Is cosmology just a plausibility argument?

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The nineteen-nineties

- $50 < H_0 < 100\ \mathrm{km\,s^{-1}\,Mpc^{-1}}$
- $0.05 < \Omega_\mathrm{m} < 1.0$
- COBE had masured CMB black-body and some fluctuations.
- Only old turks imagined $\Lambda > 0$.
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- Galaxies were discovered at $z \sim 3$.
- Roger asked me three questions...

Roger's questions

1. "Where are the young radicals?"
   - "All we have are *young fogeys* and *old turks*."

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2. "Why don't you sail around the Horn on *The Beagle*?"
   - "When you come back, write *On the Origin of Galaxies*."
3. "Isn't that just a *plausibility argument*?"

Bayesian science

- (I will *not* talk about the debate between Bayesians and frequentists!)

Bayesian science

- You must reason about propositions for which you cannot establish definitive truth or falsity.
  - want to represent plausibilities as real numbers
  - want common-sense criteria to hold
  - want consistency criteria to hold
- You are driven to Bayesian inference.
  - Cox, Jaynes, "Dutch book" theorems

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  - Cox, Jaynes, "Dutch book" theorems
- If the cosmology community is *rational*, it is *Bayesian*.
  - (I mean in the *big-picture* sense.)

The impossibility of realism

- Bayesian inference is provably correct.
  - returns true answers when the hypotheses are *exhaustive* and mutually exclusive
  - they *never are*
  - they can't be (Kolmogorov complexity and the like)
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- We are *signal encoders*, not *priests*.
  - all knowledge is *practical* knowledge
  - inference and signal encoding are exactly homologous

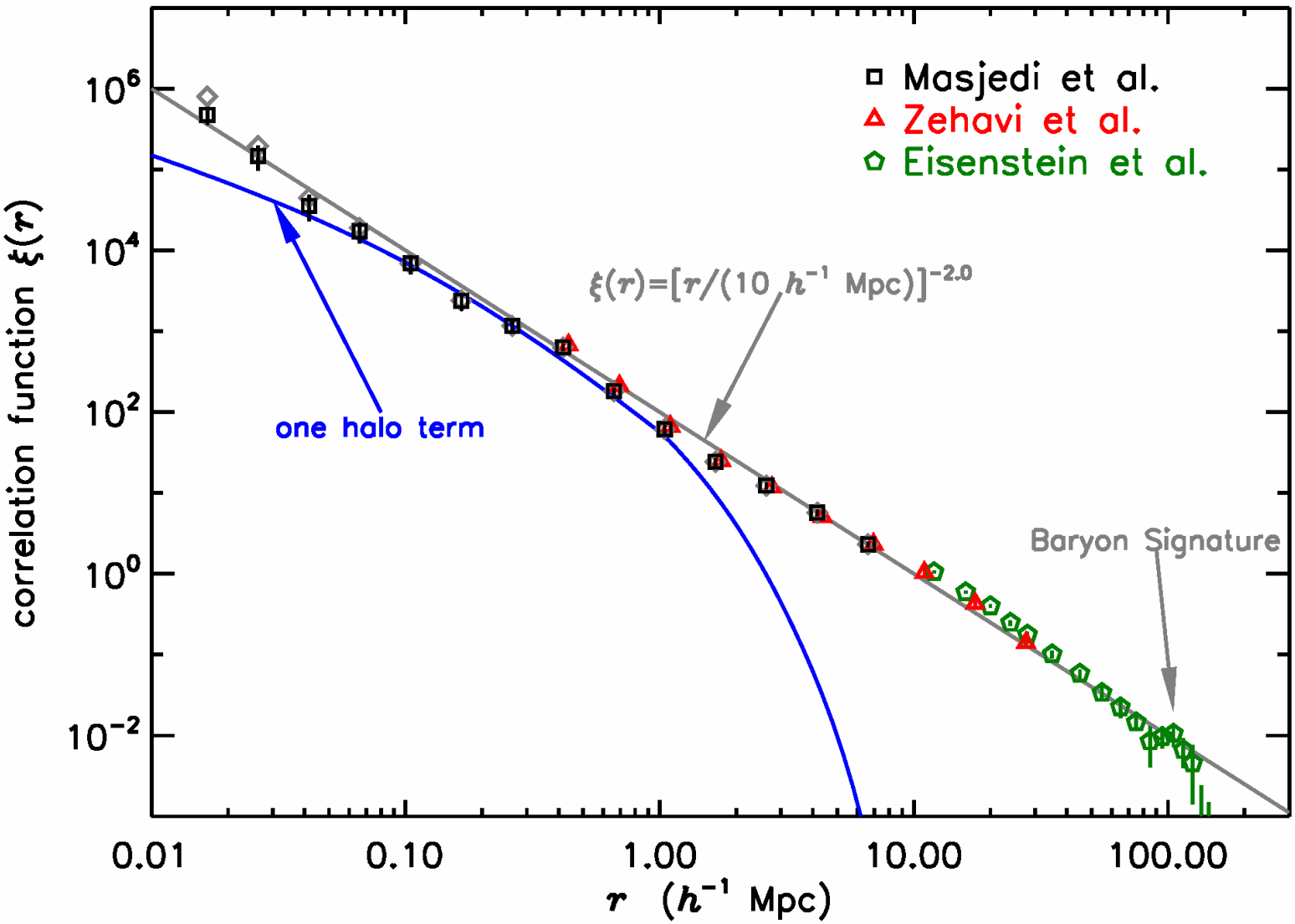
Expansion

- Expansion is established with great certainty.
  - spectral shifts look Doppler, generally redward
  - redshifts increase with distances
  - Tolman Test satisfied
  - CMB spectrophotometry
  - high-redshift galaxy molecular temperatures
  - ΛCDM works in an expanding background
  - all (known) cosmological solutions to general relativity expand or contract
- It has no competitors as an explanation.
  - "tired light" is not a model
- Any more successful explanation will include expansion as an approximation or limit.

Fractals

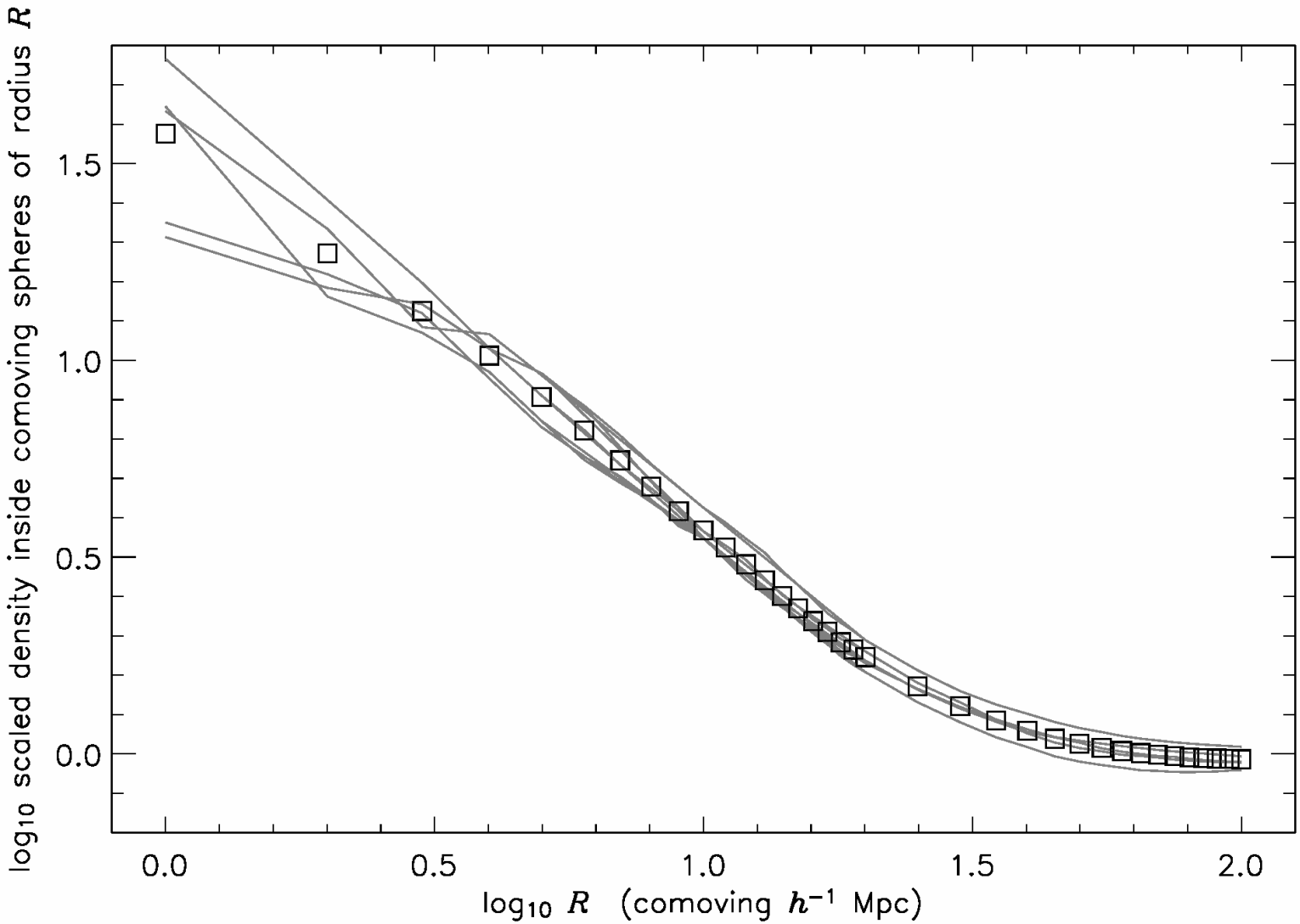
- The existence of a mean density is a fundamental prediction of every physical theory of cosmology.
- Not all tests of this mean density are (trivially) passed.
  - for example, does the correlation function go negative?
  - Sylos Labini *et al* 2009, arXiv:0903.0950
- There is no inhomogeneous theory of *any kind*.
  - there are *no* inhomogeneous solutions to general relativity
  - can't rely on any properties of redshifts or magnitudes
  - absolutely no observation can be predicted in this picture!
  - (even the observations that are taken to support it!)
- Fractals have incredibly low posterior probability.

Why you might be tempted



Masjedi *et al* 2006, ApJ, 644, 54

Why you shouldn't be tempted



Hogg *et al* 2005, ApJ, 624, 54

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- There is no (strong) evidence against a mean density.
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- This example (perhaps disturbingly) reveals our *pragmatism*.
  - (consider the case in which the data *did* look fractal)

Large extra dimensions

- Do we live on a subspace of a higher-dimensional space?
- The most mature theory is DGP; it is up against ΛCDM.
- Different studies find different results, but in one DGP is disfavored at $\Delta\chi^2 \approx 20$.
  - Fang *et al* (2008) PRD, 78, 103509
- If this holds, are large extra dimensions ruled out?

Large extra dimensions are not ruled out

- Are large extra dimensions ruled out?
- No: Neither DGP nor ΛCDM is a *good fit*.
  - maybe there is a third model that beats both, or
  - maybe they are both missing important physics, or
  - maybe there are data problems to marginalize out
  - recall, we are Bayesians, so we can't reject *all* models
- No: The DGP calculations are based on an effective theory.
  - there might be other effective theories generated by DGP
  - there might be other fundamental theories that generate that effective theory
  - recall, we ain't realists

The new young turks

- "Mature science" does not mean "boring science".
  - ΛCDM is incredible but off theory by 120 orders of magnitude
  - precision of the fit sharpens the questions
  - fractals and large extra dimensions are *by no means* the craziest things the youth are working on
  - come visit NYU!
- But Bayesian inference never tells you what to *do*.
  - all decisions involve *utility*
  - utility always has components that are extraneous to pure science

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  - all decisions involve *utility*
  - utility always has components that are extraneous to pure science
  - the young and old have systematically different utilities
  - (though the variance is larger than the bias)

Conclusions

- My conclusions:
  - give up on realism; it can't be supported
  - realism is not required for confident scientific conclusions
  - the Universe is not a fractal
  - there could certainly be large extra dimensions
- My answers to Roger:
  1. The young radicals are back.
  2. New ideas bring us closer to exhaustiveness, so sail!
  3. Yes, unfortunately, it *is* "just" a plausibility argument.