Supernovae and Isotropy

Josh Borrow

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Fitting the Friemdann equation

$$\frac{H^2}{H_0^2} = (\Omega_b + \Omega_C)a^{-3} + \Omega_k a^{-2} + \Omega_\Lambda \ . \tag{1}$$

Comoving Distance

$$r(z) = \frac{c}{H_0|\Omega_k|^{1/2}} \mathrm{sinn}\left(|\Omega_k|^{1/2} \int_0^z \frac{\mathrm{d}z' H_0}{H(z')}\right) .$$

Where sinn is defined as sinh for $\Omega_k > 0$ and sin for $\Omega_k < 0$, for $\Omega_k = 0$ this reduces to the integral and c/H_0 prefactor (Weinberg 1972). Computational precision used 1×10^{-9} for checks (even though they reduce to the same thing as $\Omega_k \to 0$).

Data

- Union 2.1 Compilation
- 580 supernovae
- redshift 0.015 to 1.414

Fitting

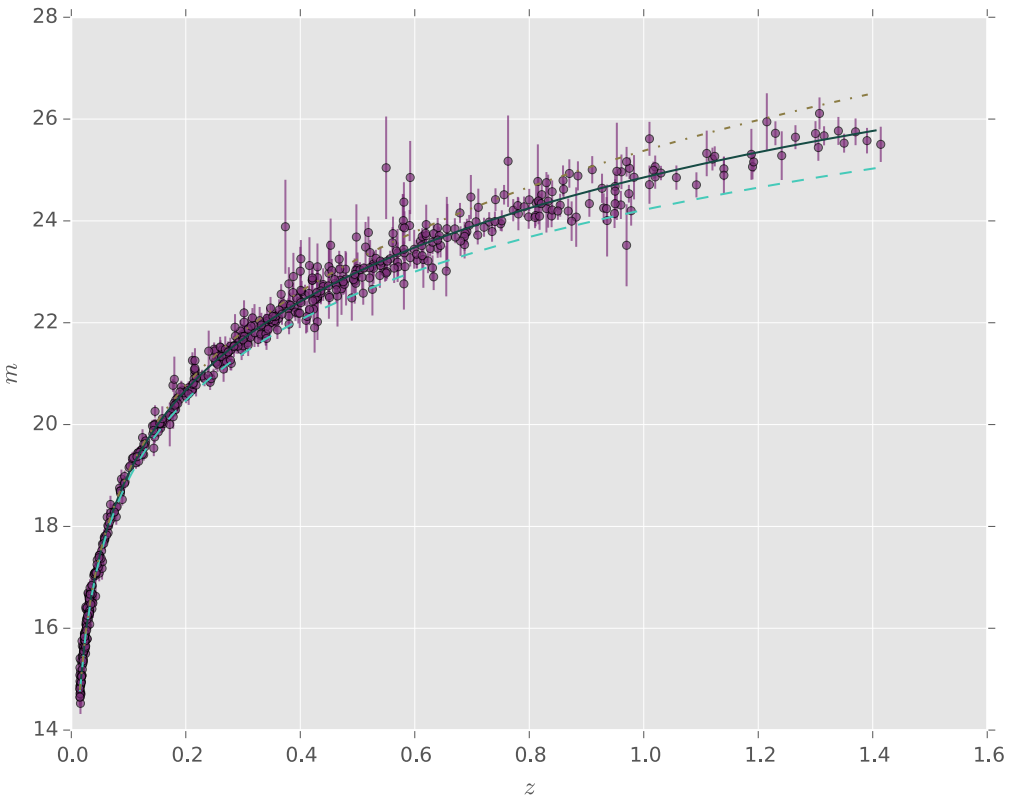


Figure: Mustard dot-dash (0, 1, 0), light blue dash (1, 0, 0), green solid best fit (0.3, 0.7, 0) with these (Ω_{b+C}, Ω_Λ, Ω_k)

Residuals

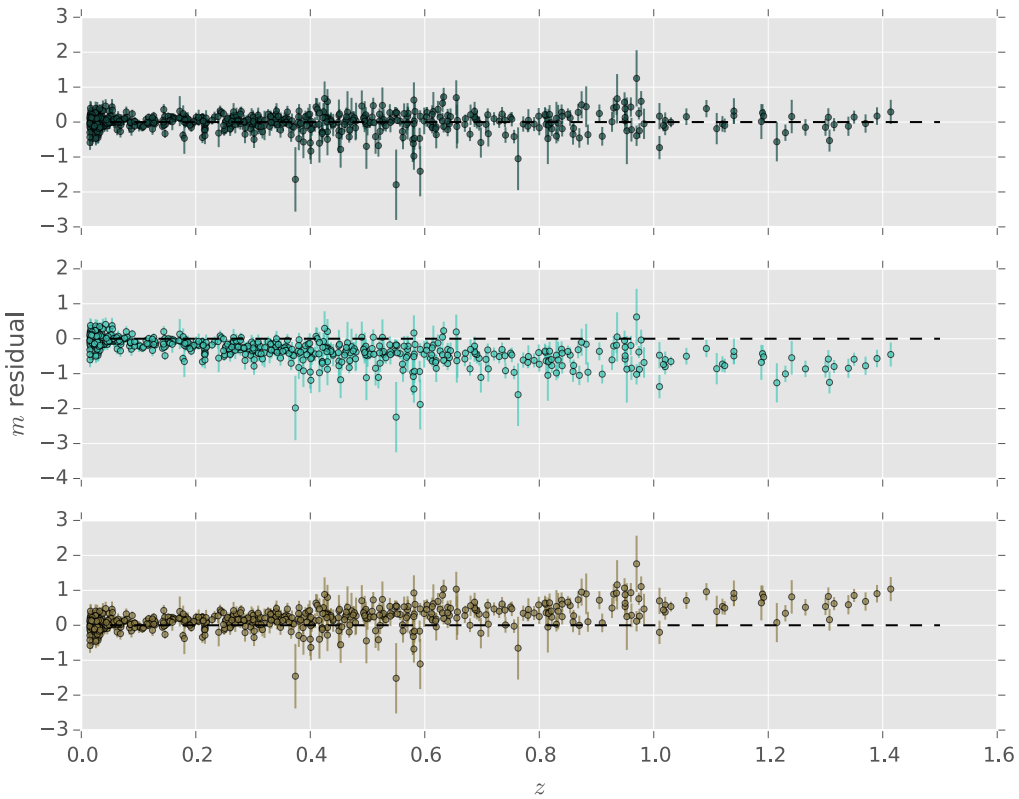


Figure: Colours the same as previous plot.

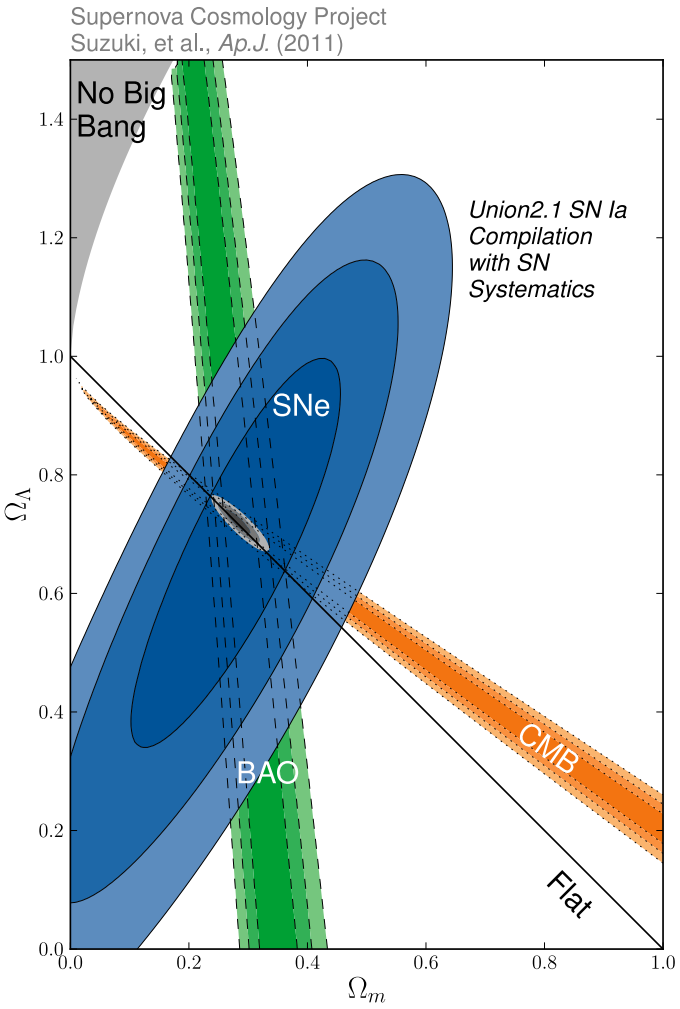
Results

- $\chi^2_{red} = 0.985$
- $\Omega_b + \Omega_C = 0.274(26)$
- $\Omega_k = 3 \times 10^{-6} \pm 0.05$ consistent with 0
- $\Omega_\Lambda = 0.726(33)$

Difficulties

- Hyper sensitive to initial conditions - many local minima
- With this much data computation time is growing (several minutes on laptop) so can spiral easily
- The errors on supernovae are too high for this kind of work!

What are those?!



Isotropy

We can study Isotropy with supernovae!
Write:

$$\mu_{th} = \bar{\mu}_{th}(1 + D(\hat{n} \cdot \hat{p})) \ , \tag{2}$$

$\hat{n}$ dipole direction and $\hat{p}$ supernova direction, with D magnitude (Lin et al. 2015).

So what?

Look at systematics to find how we need to change them to see anisotropy.
E.g. what if dust absorption is locally more anisotropic than previously thought?

Future Work

- Look at other datasets (JLA)
- Combine data from PLANCK, JLA/Union (SN1a), BAO
- Investigate significance of covariance between parameters in model
- Anisotropy tests on SN1a data
- Anisotropy tests on BAO?