Constraining the Dark Fluid

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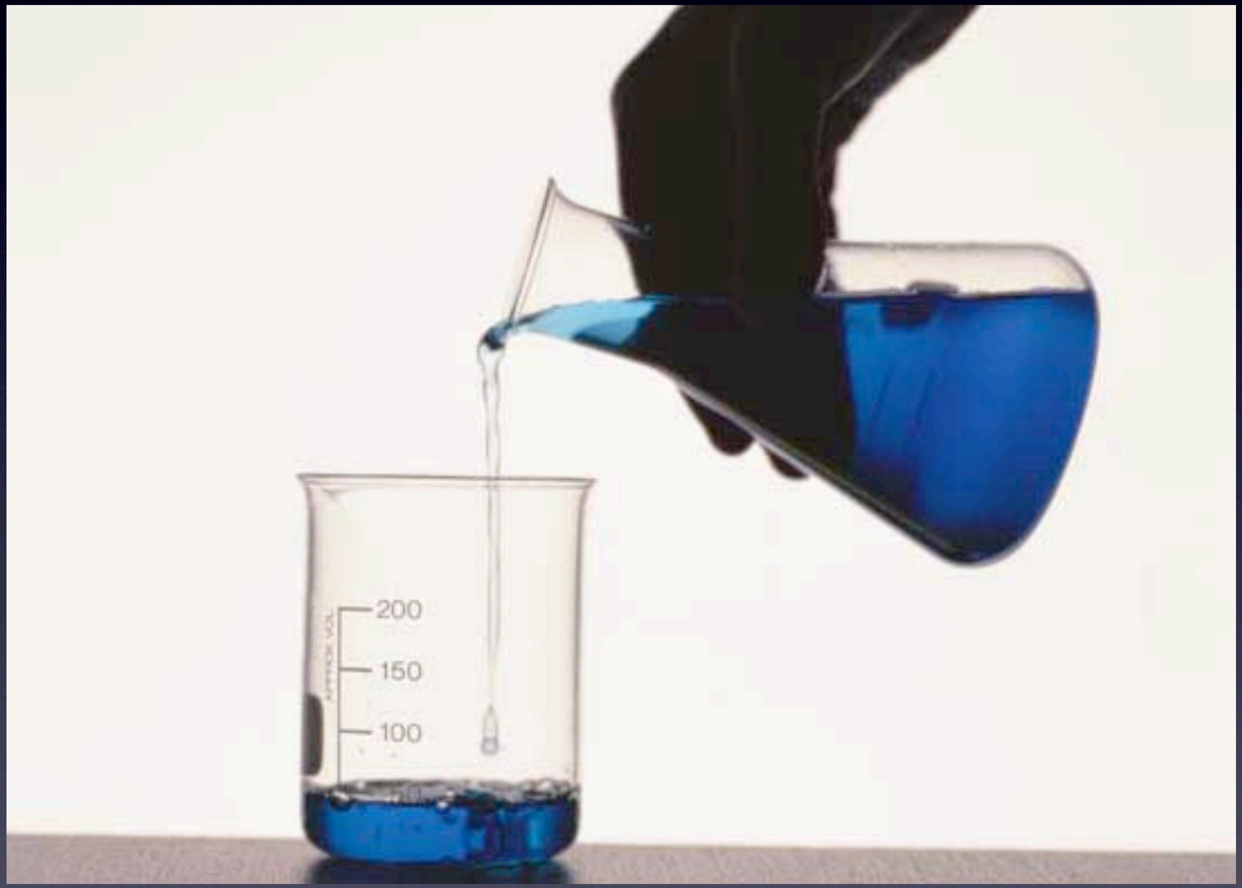
University of Sussex

The Dark Fluid



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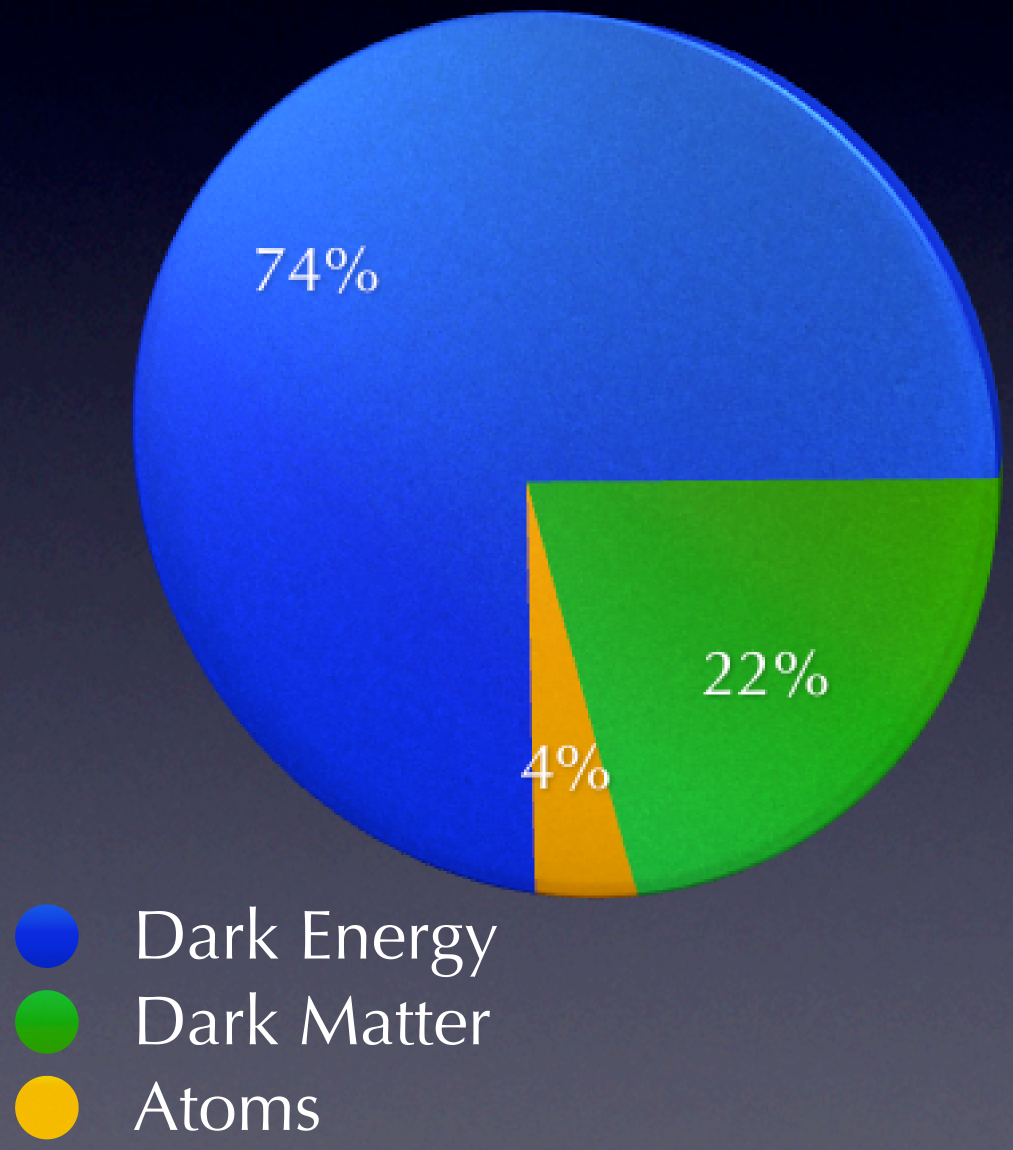

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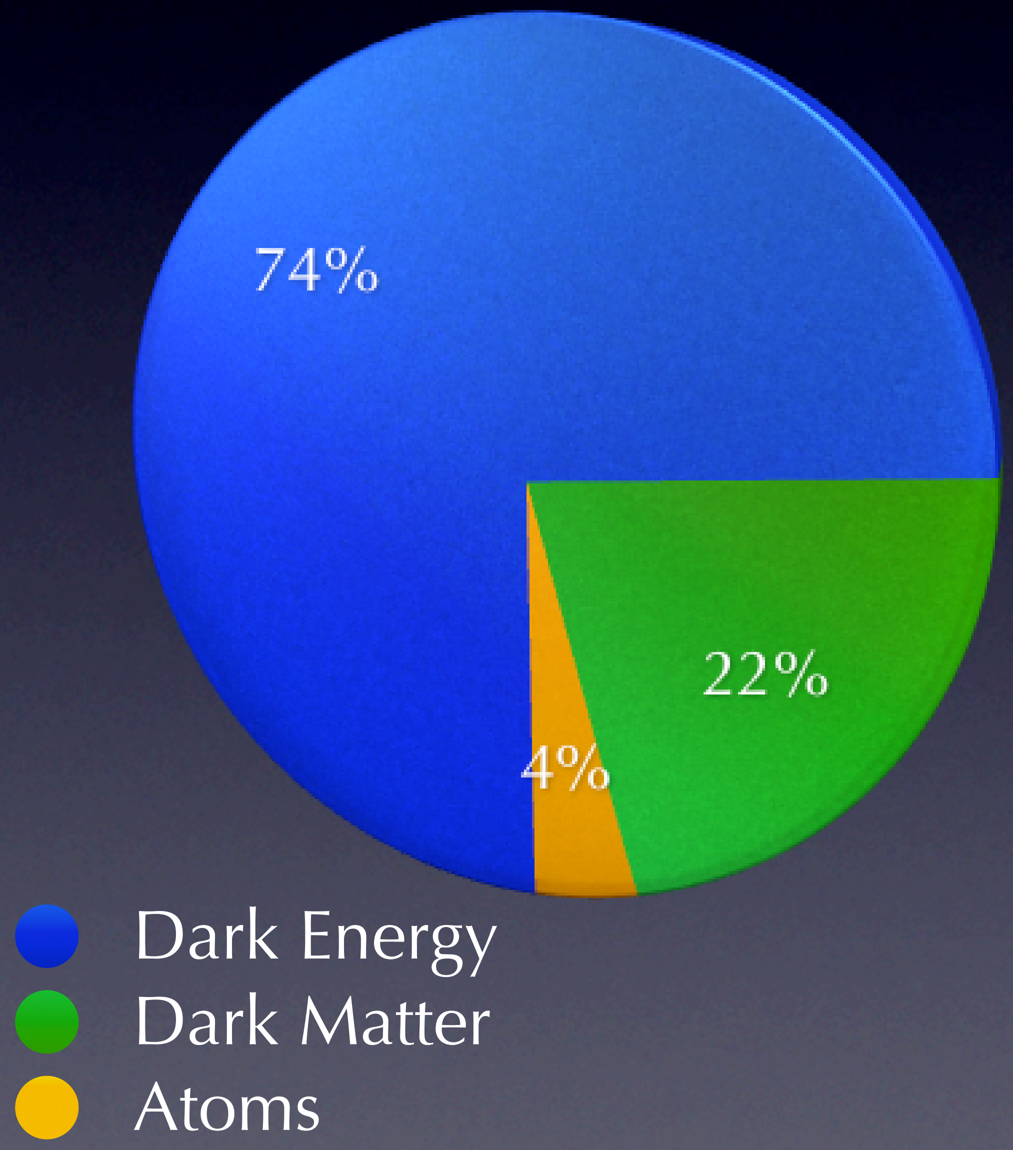

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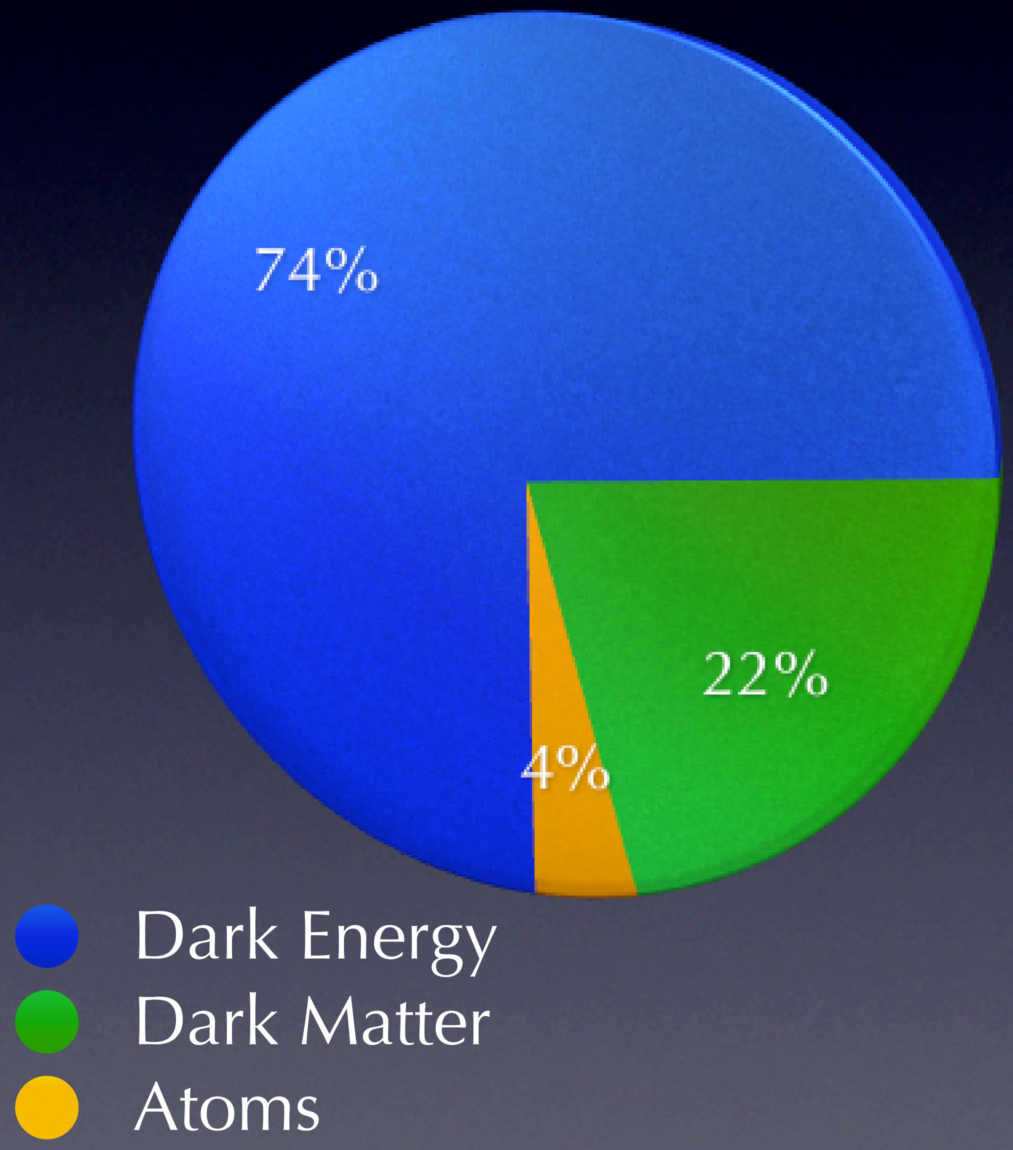

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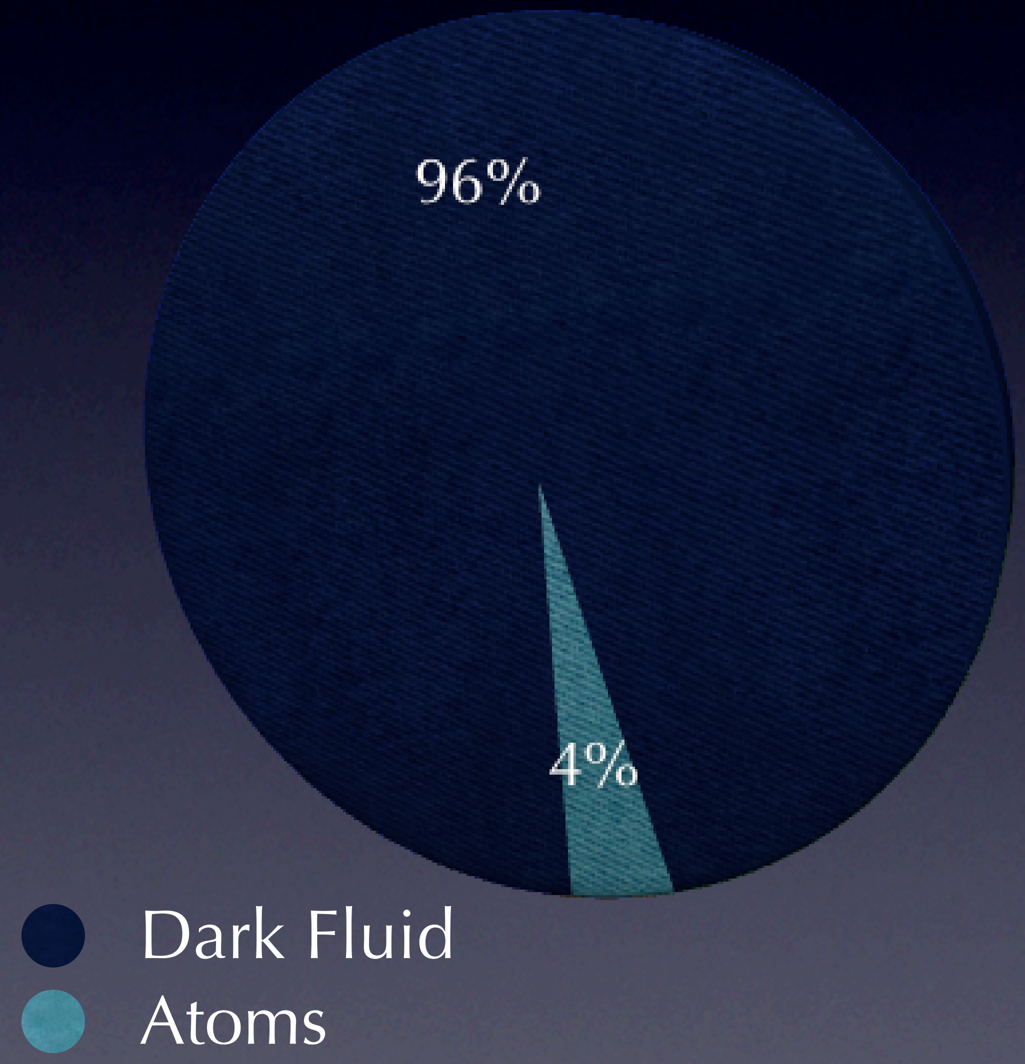

General Relativity

- Current measurements do not provide a unique decomposition between dark sector components (Wasserman (2002), Rubano & Scudellaro (2002), Kunz (2007)).
- Consider the Einstein equations

$$G_{\mu\nu} - \kappa T_{\mu\nu}^{visible} = \kappa T_{\mu\nu}^{dark}$$

- We make measurements of the left hand side, and interpret a non-zero result to be evidence for the dark sector.
- Current observations offer no guidance as to how to split the tensor among different components.

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- This is the dark degeneracy.

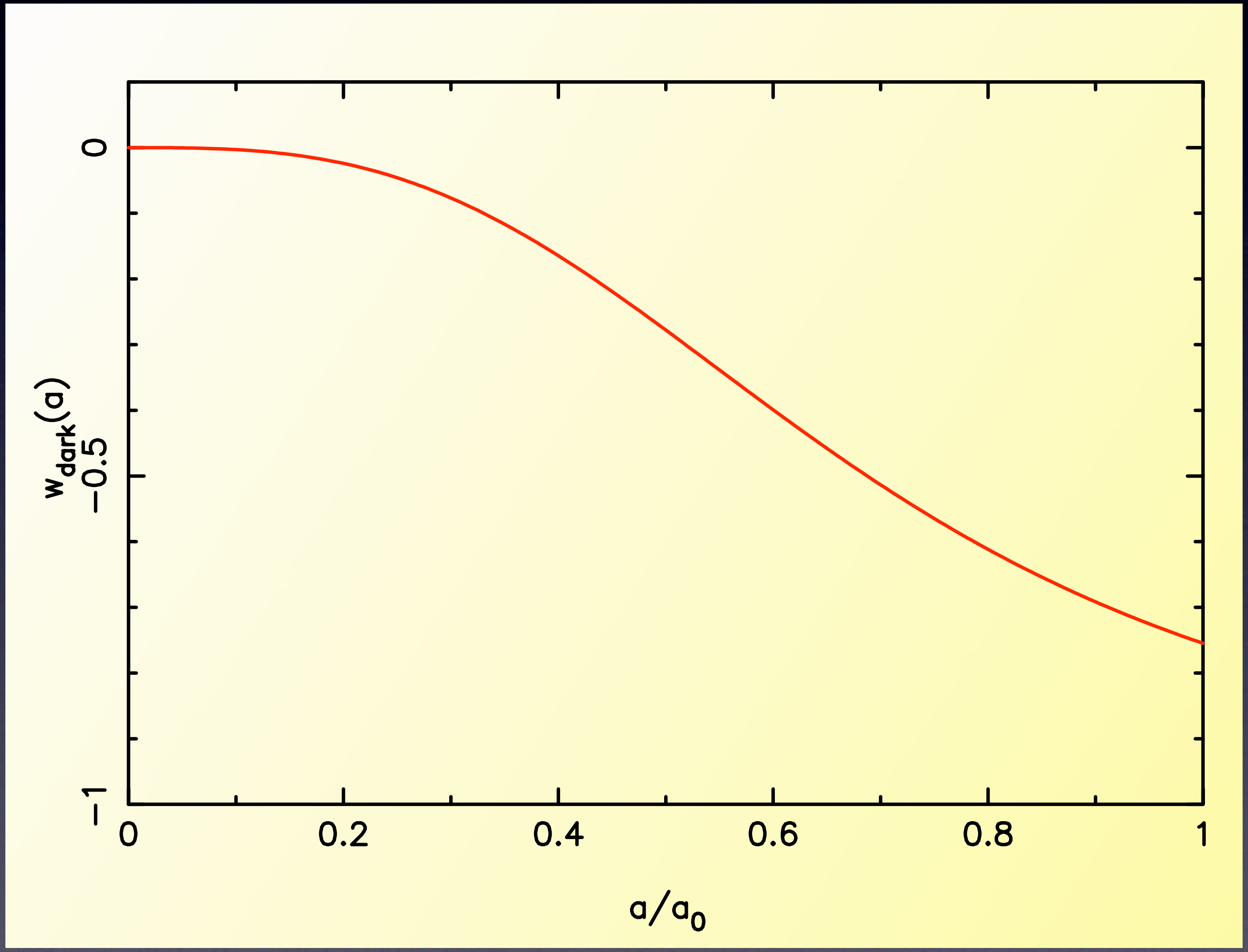
Example

- Consider a dark fluid with an equation of state

$$w_{dark} = -\frac{1-\Omega_m}{1-\Omega_m + (\Omega_m - \Omega_b)(1+z)^3}$$

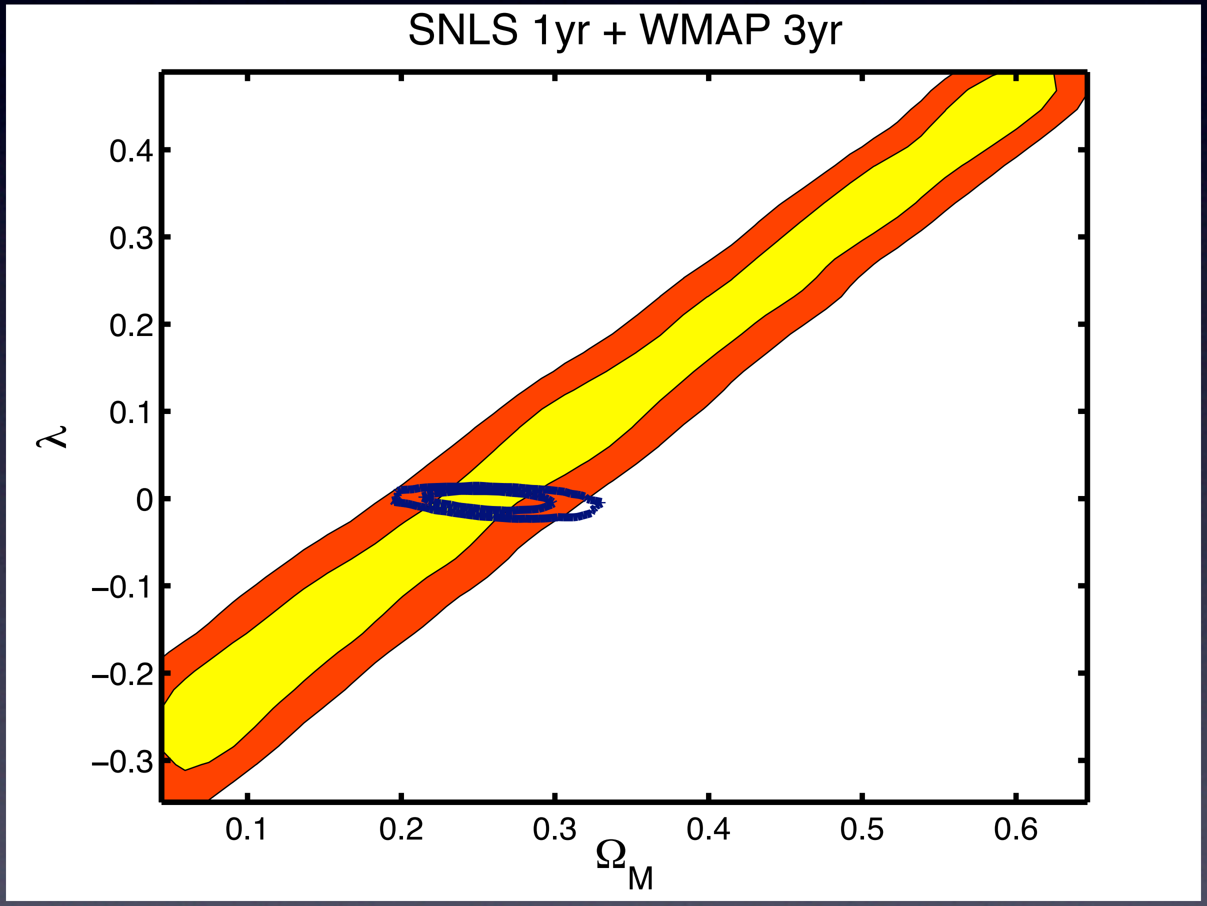
$$\cong -\frac{1}{1+0.31(1+z)^3}$$

- This will mimic the dynamics of the standard cosmological model.



Example Constraints

- In Scalar field dark energy (the open contours) the perturbations are set by the model, so the constraints on the parameters (λ & Ω_{CDM}) are very tight.
- In our example model (the filled contours), we can set the speed of sound to be zero, so we have an exact degeneracy between dark energy and dark matter.



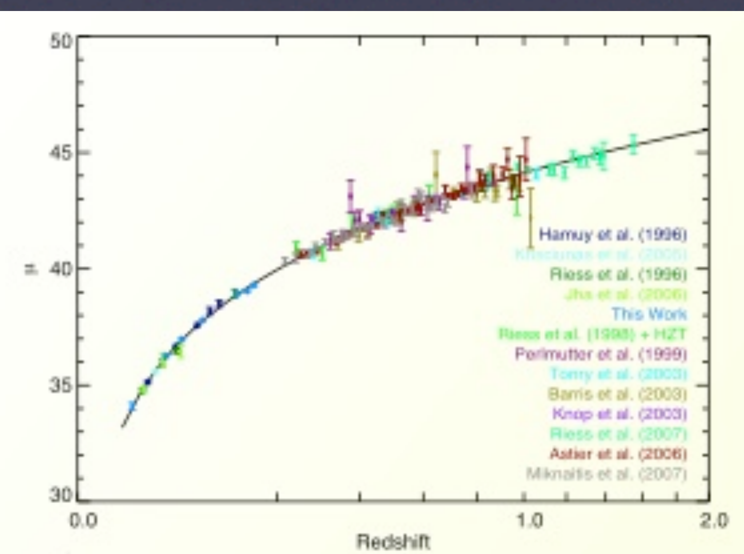
from Kunz (2007)

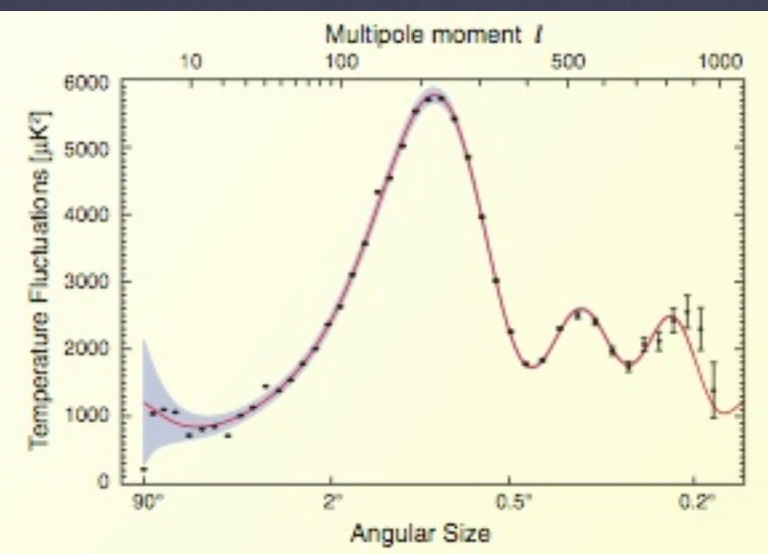
Analysis

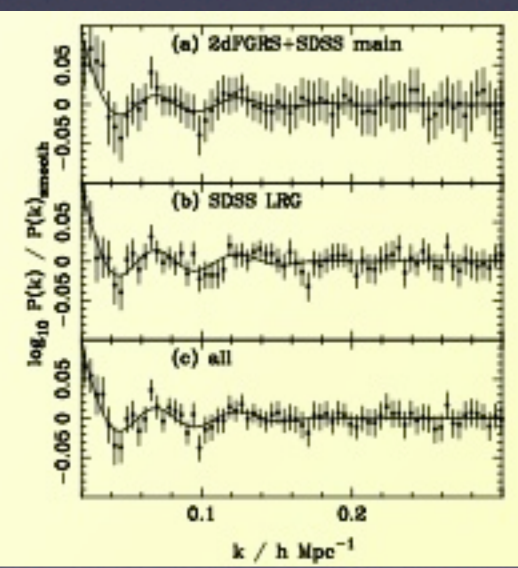
- We use only kinetic data, an attempt to put constraints on the equation of state w(a) for the single dark fluid (i.e. $\Omega_{CDM}=0$).
- We parameterize the equation of state as a Taylor series expansion in (1-a)

$$w(a) = \sum_i w_i (1-a)^{i-1}$$

- We use data from Type-Ia Supernovae (the UNION sample of 307 SN), Baryon Acoustic Oscillations (the SDSS-2dF sample) and positions of the CMB peaks (WMAP5).

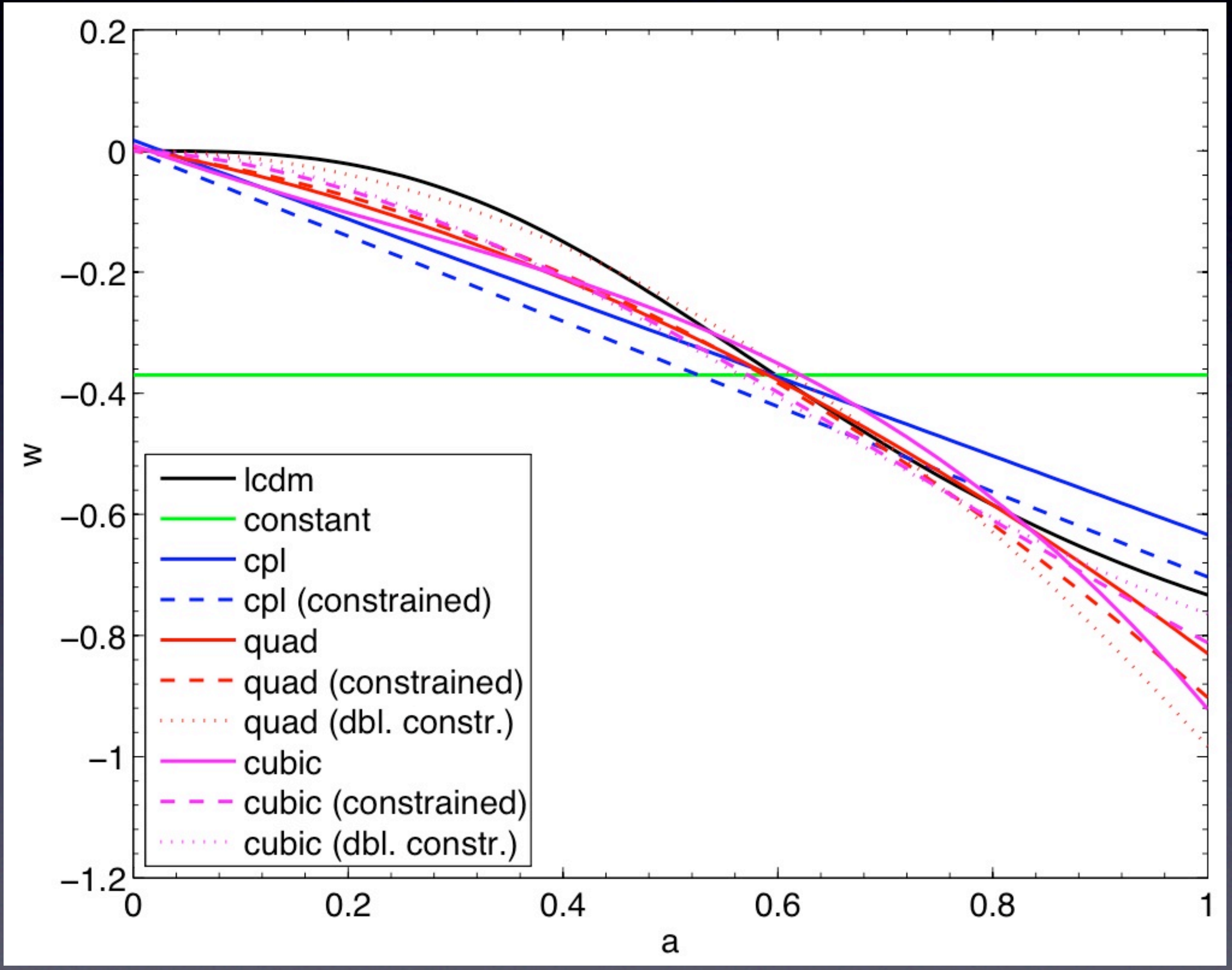




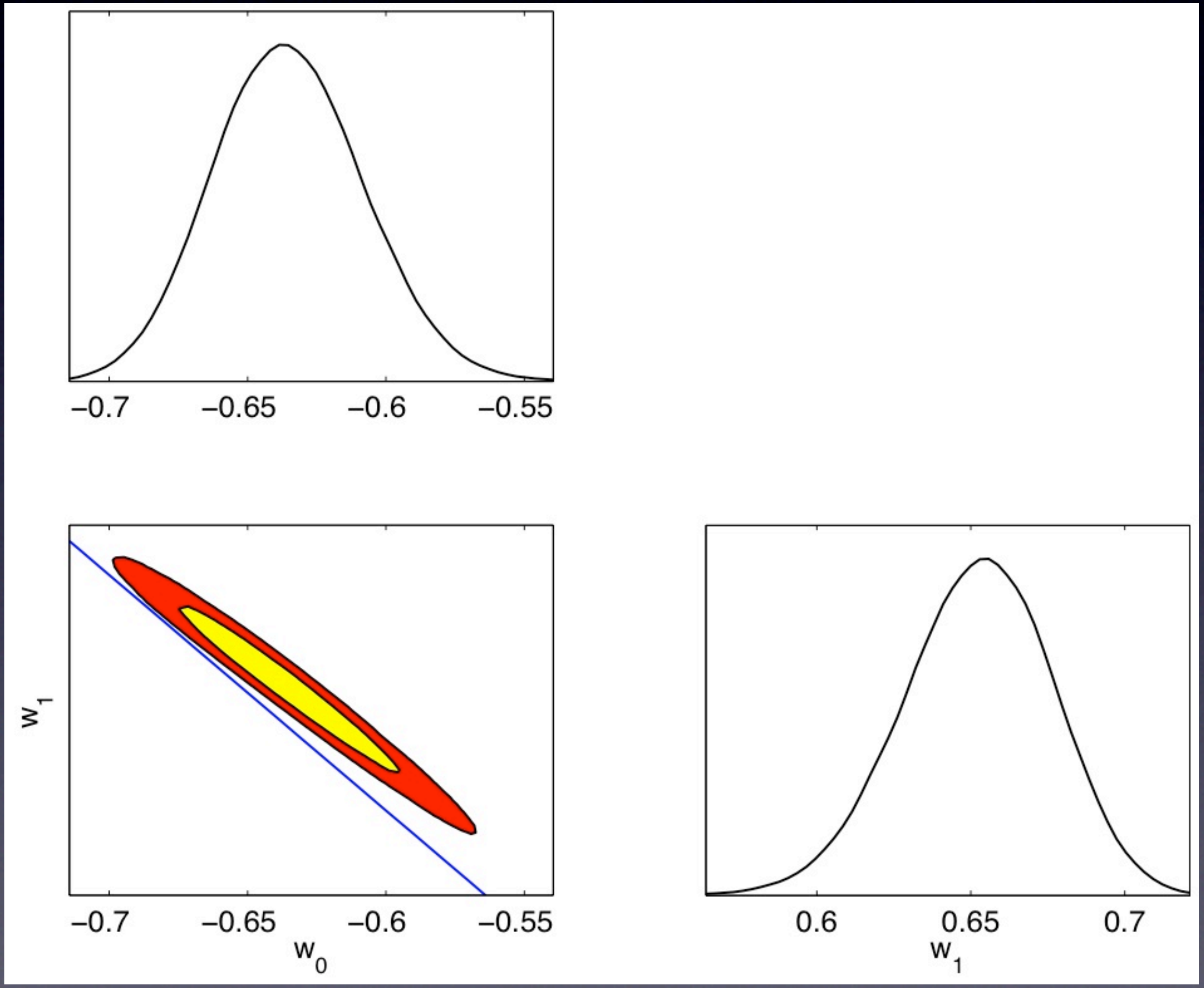


Best fit cases

Model	Dark sector parameters	best fit χ^2
ΛCDM	1	317.6
Constant w	1	545.0
Linear (CPL)	2	318.4
Constrained Linear	1	330.3
Quadratic	3	315.3
Constrained Quad	2	315.6
Doubly-constrained Quad	1	320.2
Cubic	4	315.2
Constrained Cubic	3	315.5
Doubly-constrained Cubic	2	315.5



Constraints



Linear (CPL)

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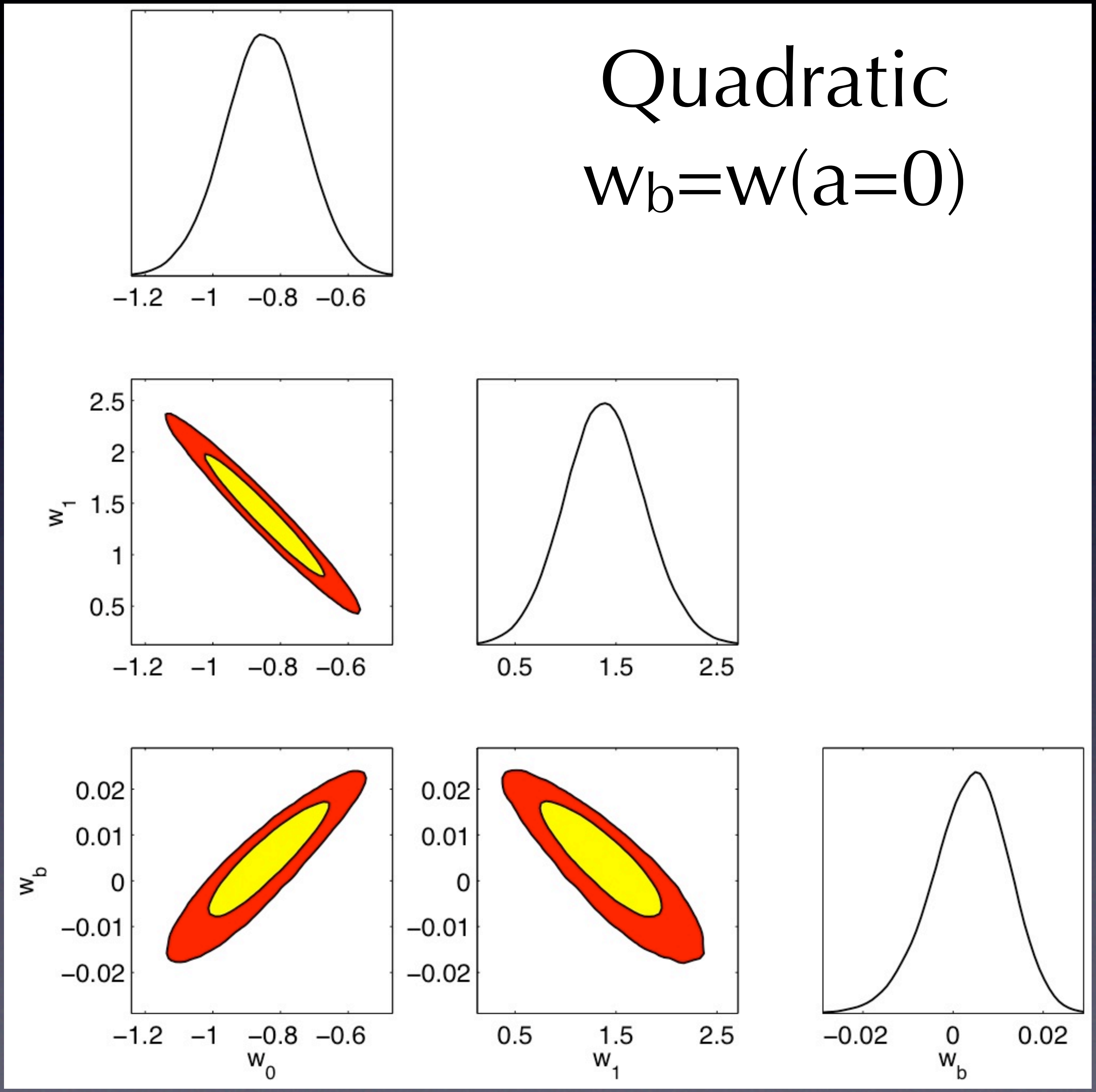

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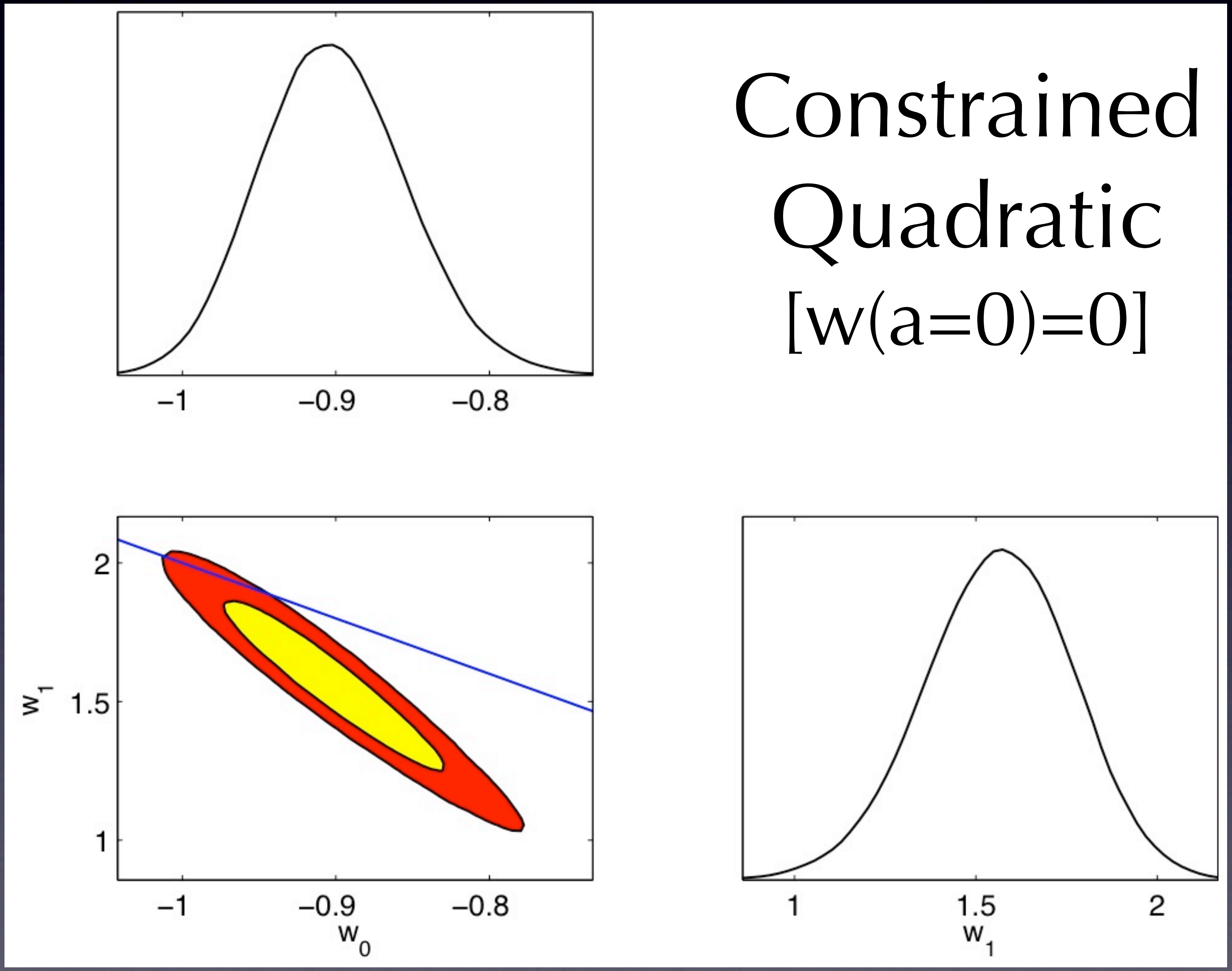
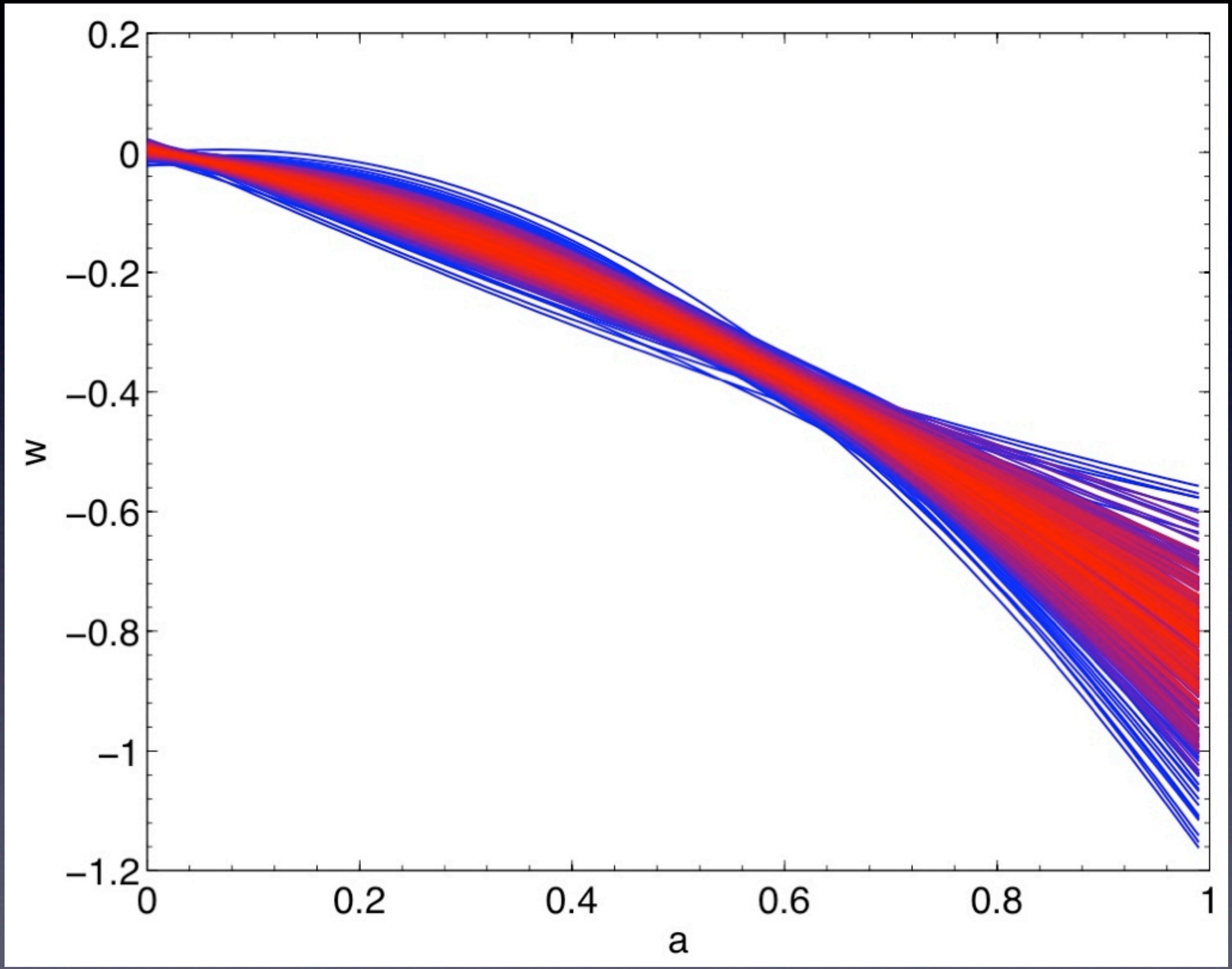


Model spread



Random quadratic models drawn from chain

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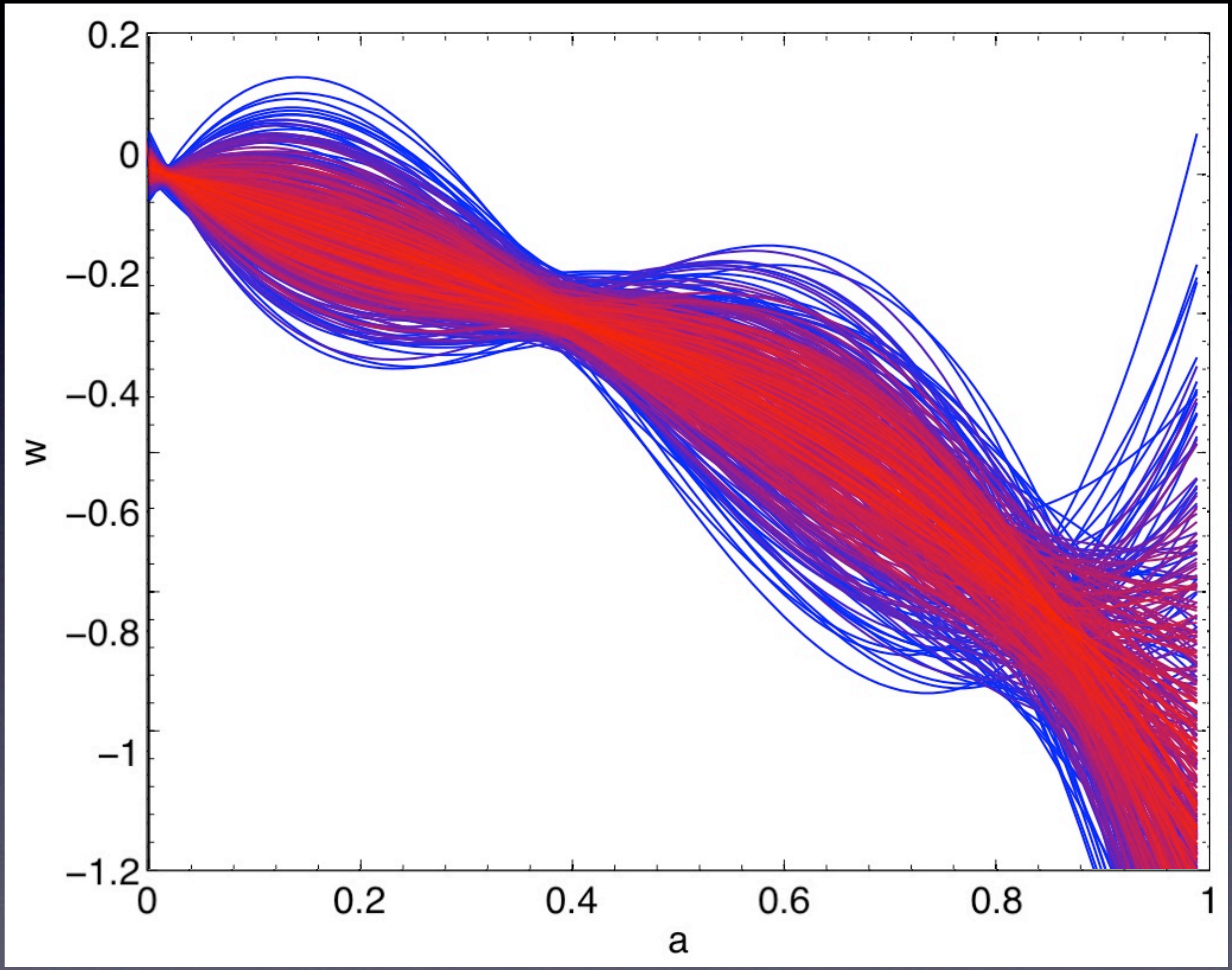
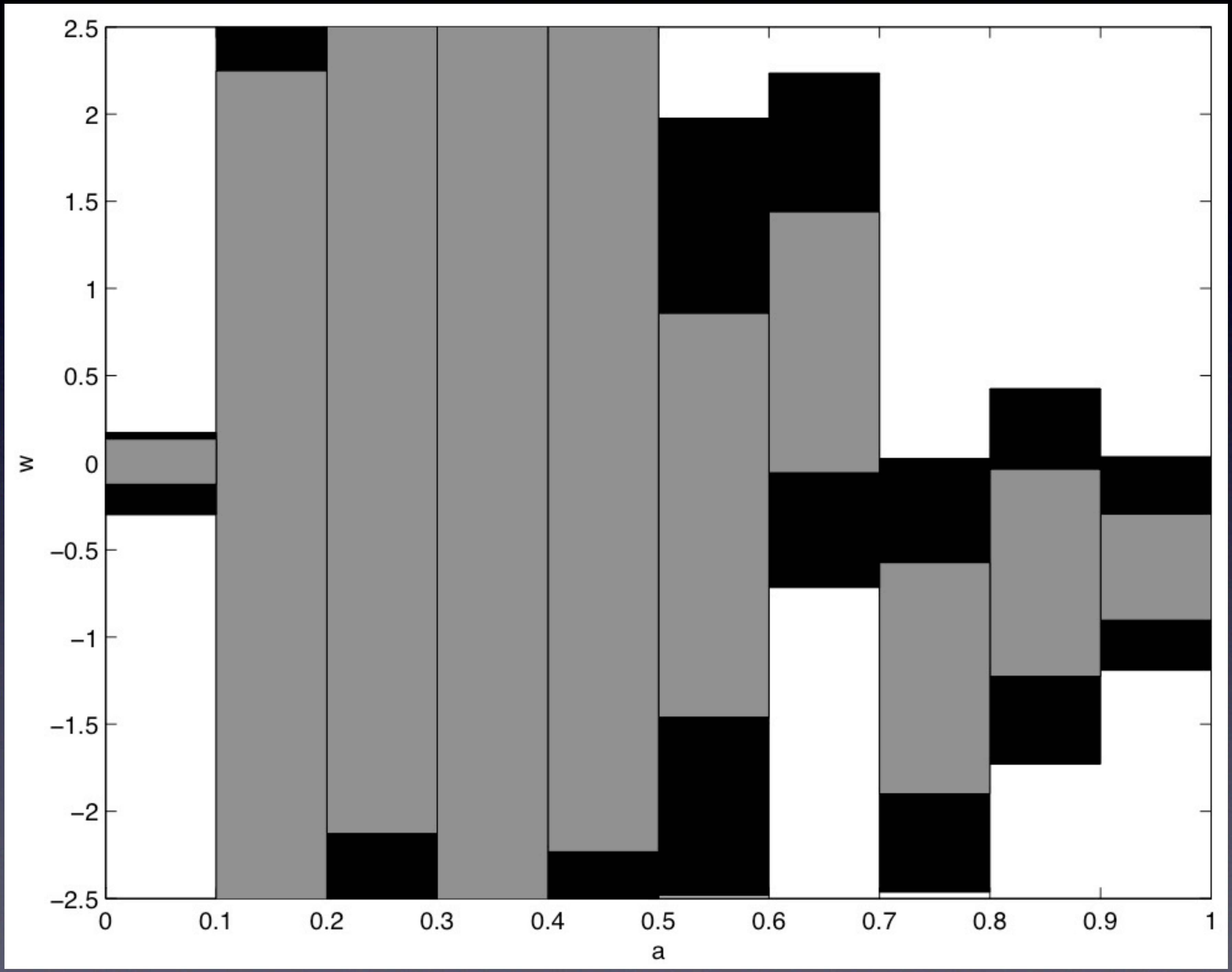


Random cubic models drawn from chain

Binned results



w(a) divided into 10 bins

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- We found the dark sector must behave as dark matter ($\rho \propto a^{-3}$) at early times, and force acceleration ($w \cong -0.8$) at late times.
- ΛCDM remains the simplest explanation for the current observations.
- Direct detection of dark matter particles would break the dark degeneracy.