CMBと大規模構造との相関を用いた宇宙論パラメータの推定

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Quintessence

- Quintessence is described by an ordinary scalar field φ minimally coupled to gravity

action

$$S = \int \mathrm{d}^4 x \sqrt{-g} \left[-\frac{1}{2} (\nabla \phi)^2 - V(\phi) \right] \quad \Rightarrow \quad \ddot{\phi} + 3H\dot{\phi} + \frac{\mathrm{d}V}{\mathrm{d}\phi} = 0$$

- In the flat Friedmann background

energy density

$$\rho = \frac{1}{2}\dot{\phi}^2 + V(\phi)$$

pressure density

$$p = \frac{1}{2}\dot{\phi}^2 - V(\phi)$$

- equation of state

$$w_\phi = \frac{p}{\rho} = \frac{\dot{\phi}^2 - 2V(\phi)}{\dot{\phi}^2 + 2V(\phi)}$$

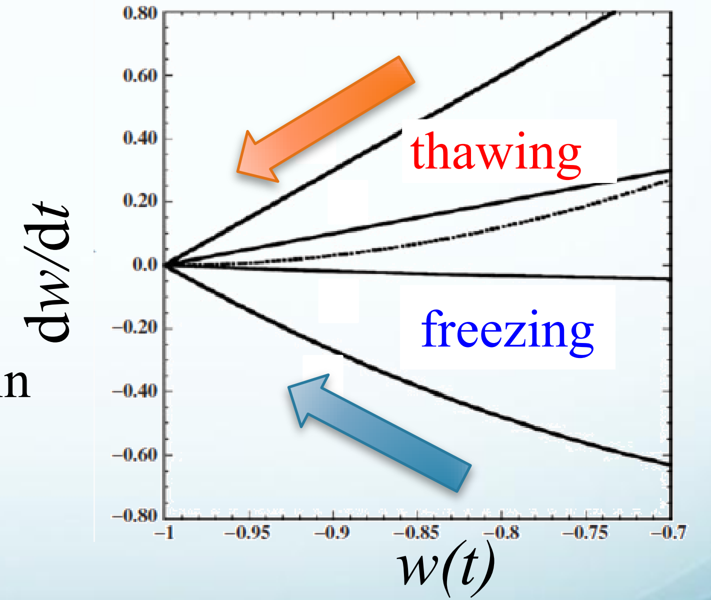
Potential of Quintessence

- many quintessence potentials have been proposed

(i) Model I. "thawing models"

the field (with mass m_φ) has been frozen by Hubble friction until recently and then it begins to evolve once H drops below m_φ.

- $V(\phi) = V_0 + M^{4-n}\phi^n \ (n > 0)$
- $V(\phi) = M^4\cos^2(\phi/f)$



(i) Model II. "freezing models"

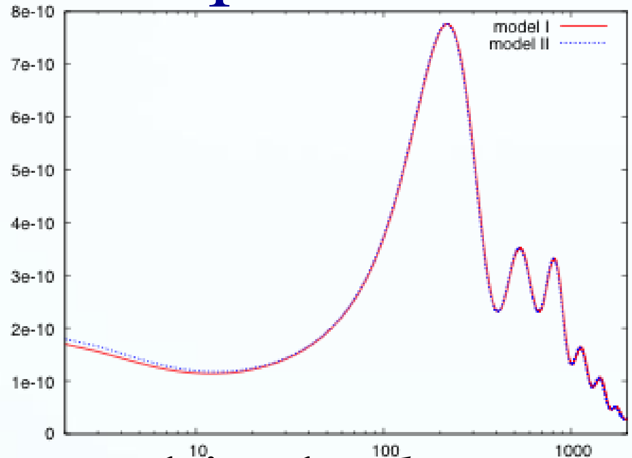
the field was rolling along the potential in the past, but the movement gradually slows down after the system enters the phase of cosmic acceleration

- $V(\phi) = M^{4+n}\phi^{-n} \ (n > 0)$
- $V(\phi) = M^{4+n}\phi^{-n}\exp(\alpha\phi^2/m_{pl}^2)$

Effects for CMB

Temperature

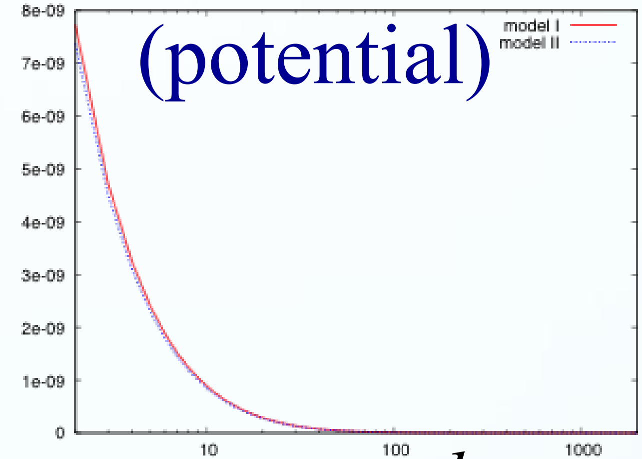
$l(l+1)C^{TT}_l/2\pi$



multipole: l

CMB lensing (potential)

$l(l+1)C^{\psi\psi}_l/2\pi$



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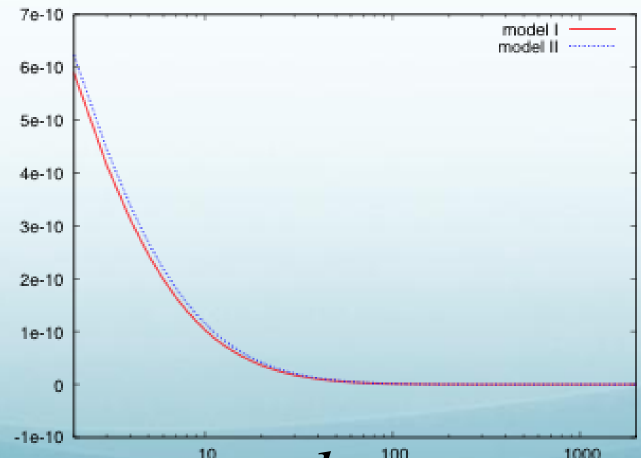
Tψ cross-correlation

$l(l+1)C^{T\psi}_l/2\pi$



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Parameterization of DE

- parameterize equation of state of dark energy
  - Instead of expressing the Hubble parameter H in terms of z , one can parametrize the equation of state of DE

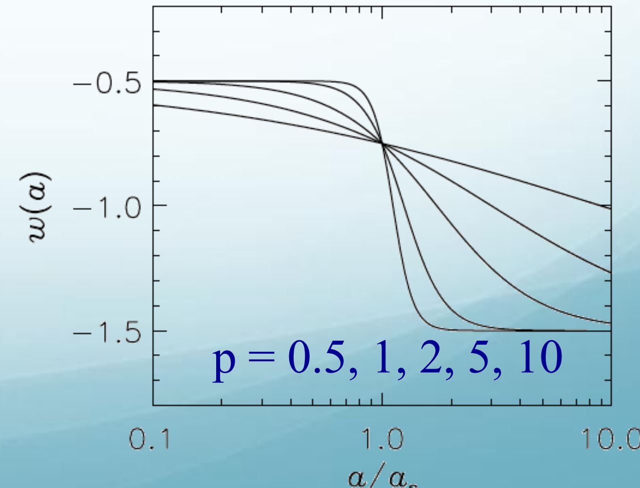
$$H^2(a) = H_0^2\left[\Omega_{m0}(1+z)^3 + (1-\Omega_{m0})\exp[3\int_0^z \frac{1+w(z')}{1+z'}dz']\right]$$

- Chevallier and Polarski (2001) & Linder (2003)

$$w(a) = w_0 + w_a(1-a)$$

- Hannestad and E. M¨ortsell (2004)

$$w(a) = w_0 w_1 \frac{a^p + a_s^p}{w_1 a^p + w_0 a_s^p}$$

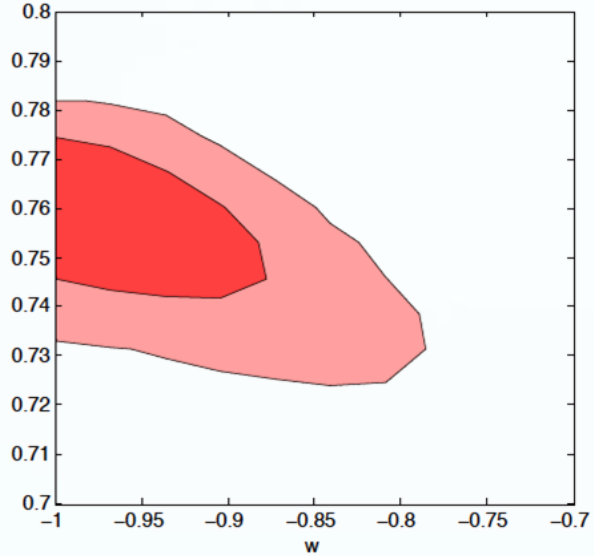


Method of our Analysis

- Likelihood analysis:
  - Fiducial model is ether of quintessence models.
  - estimate the confidence region of parameterized w(a) model for each fidutial models.
  - assume future survey and include all of auto- and cross- correlations.
- If the different tendency for the constraints of parameters which are different quintessence models,

it allow us to distinguish the different models of potential.

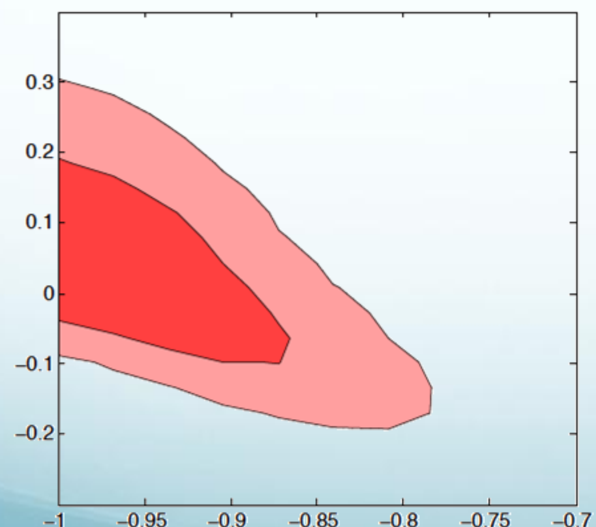
Constraints: CMB + SN Model. Ⅰ

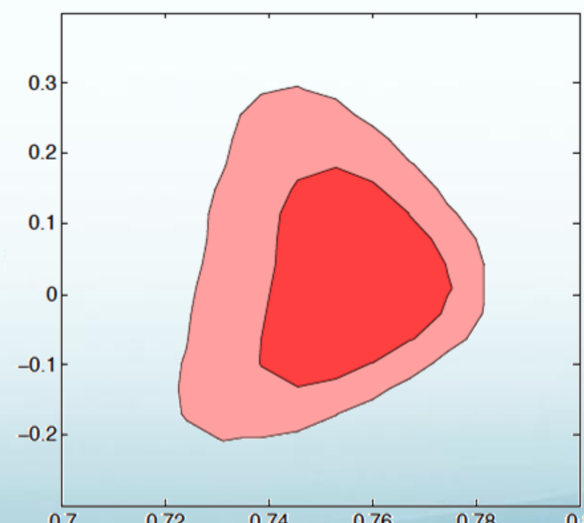


Model I. "thawing models"

$$V(\phi) = V_0 + M^{4-n}\phi^n$$ **type**

$$V(\phi) = M^2\phi^2$$



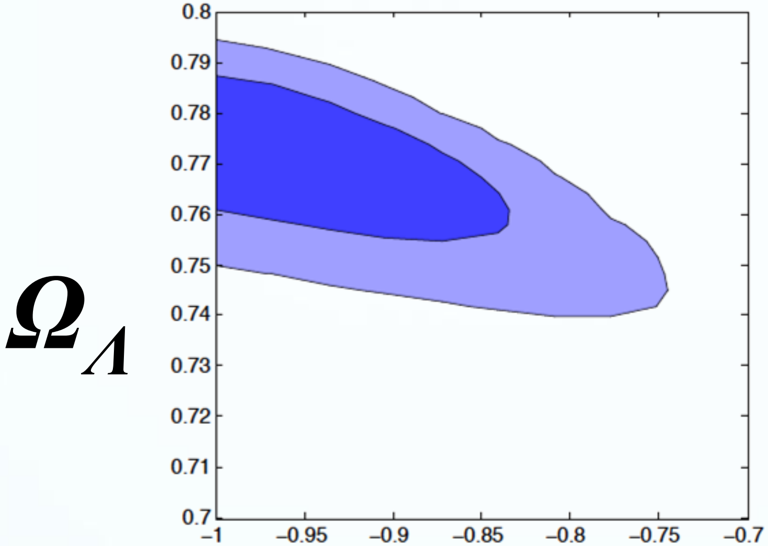


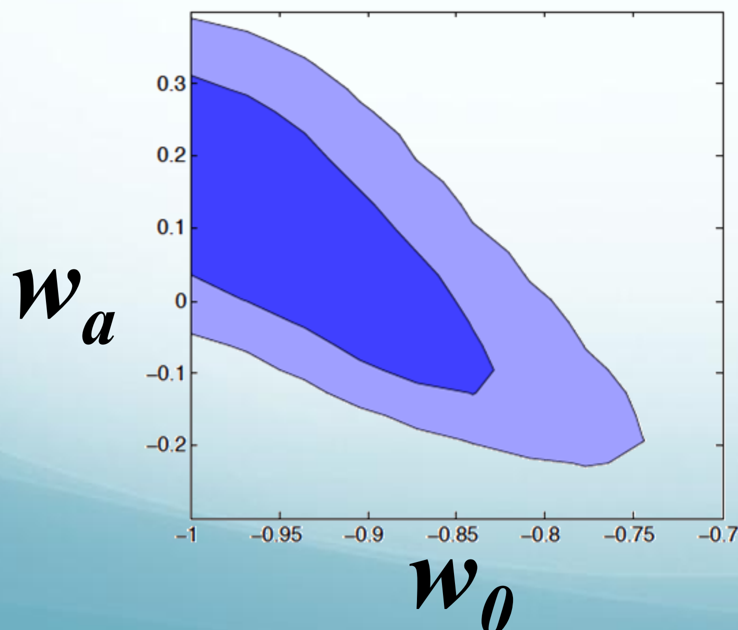
Constraints: CMB + SN Model. Ⅱ

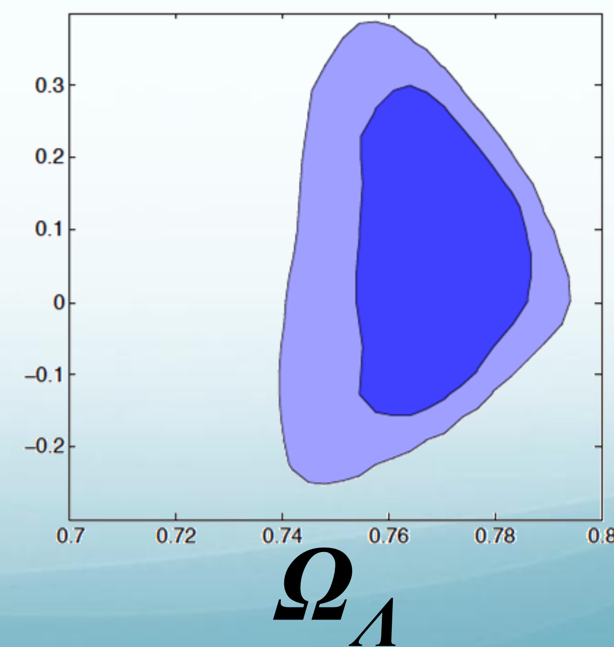
Model II. “freezing models”

$$V(\phi) = M^{4+n}\phi^{-n}$$

$$V(\phi) \propto \phi^{-1/3}$$

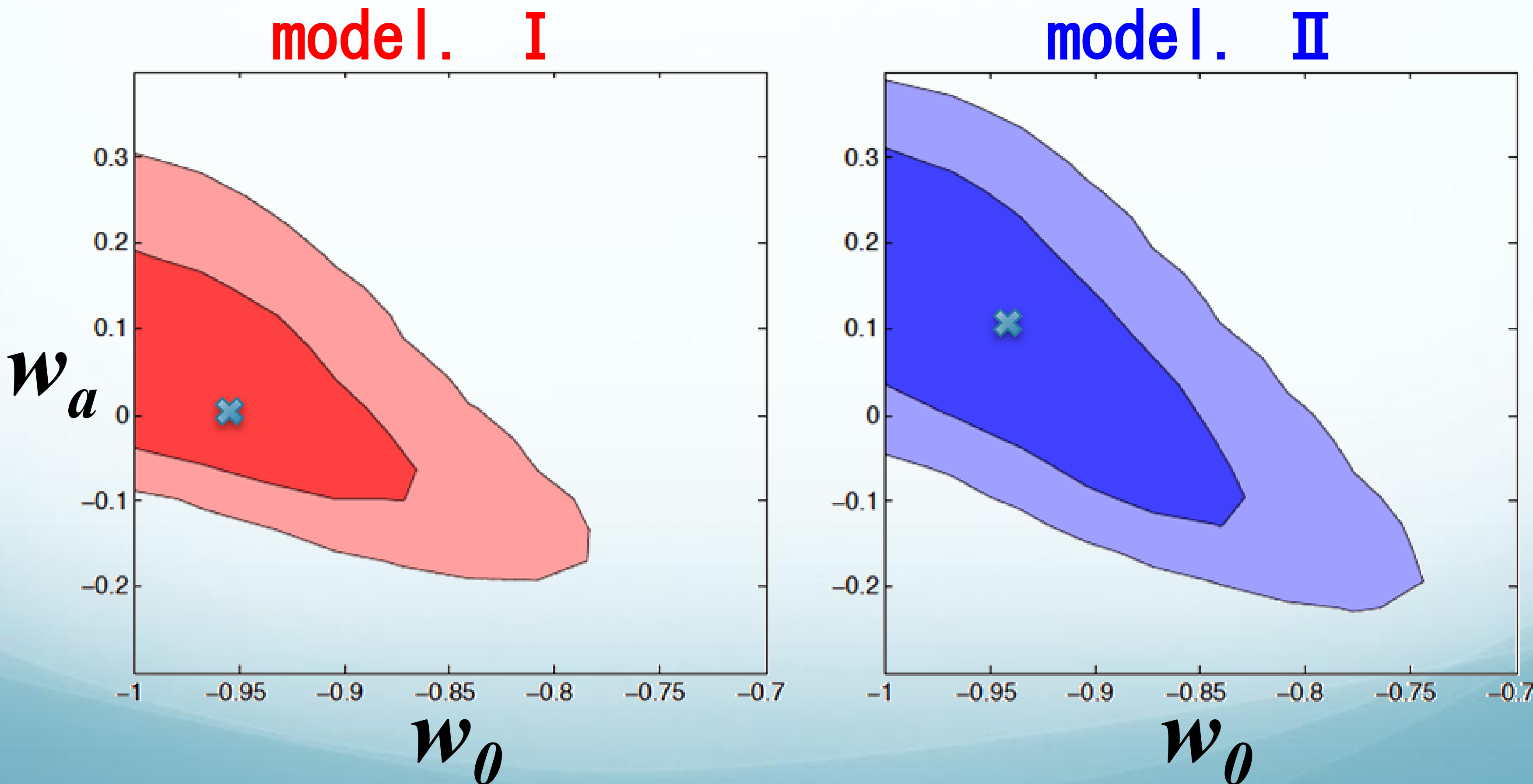






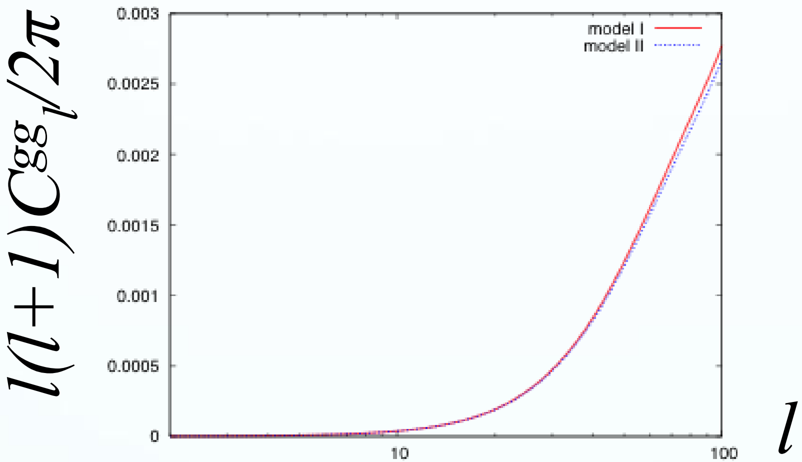
Constraints: CMB + SN

- Can you distinguish the difference of the potentials from these observations ?

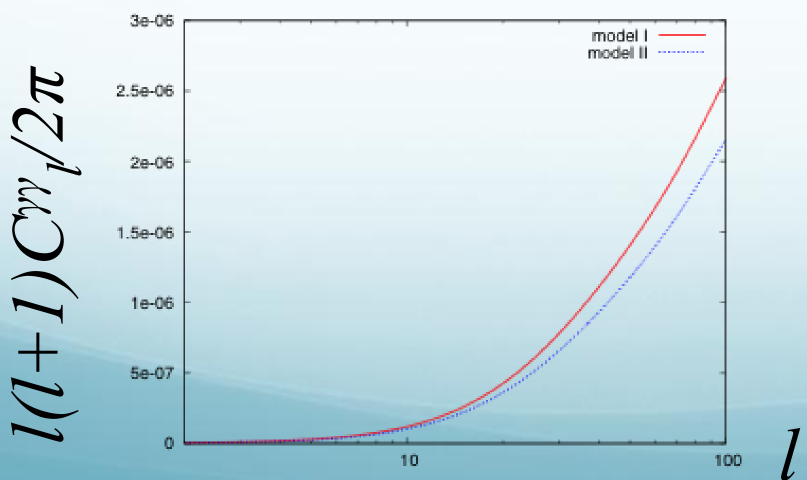


Effects for auto-correlations of LSS

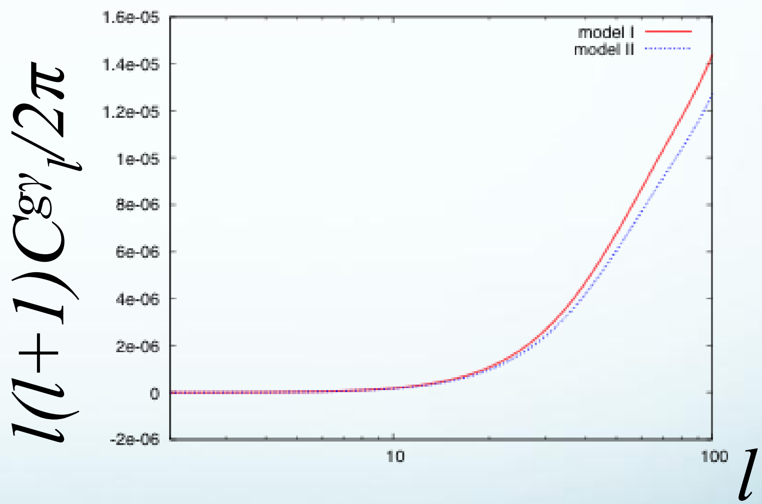
- Galaxy distributions



- weak lensing (cosmic shear)

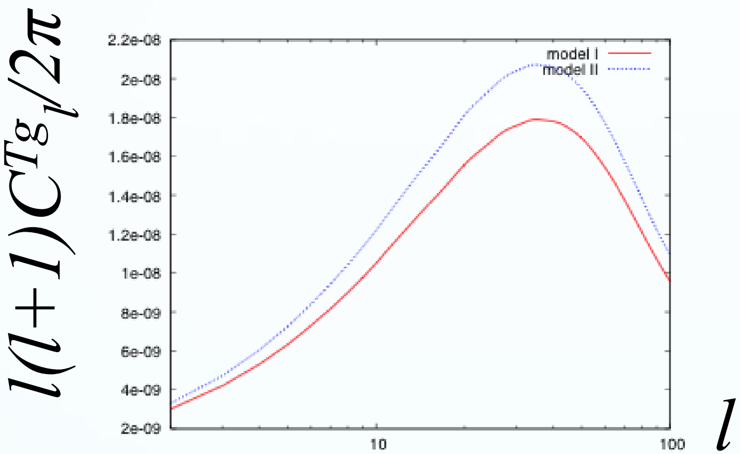


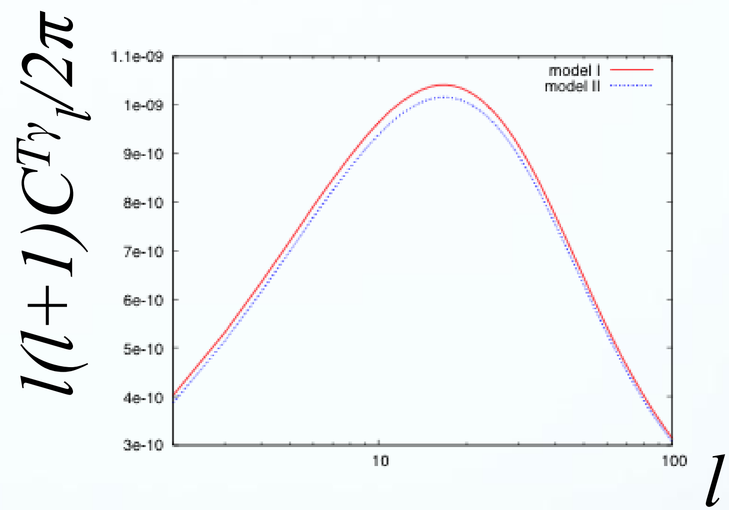
galaxy-cosmic shear



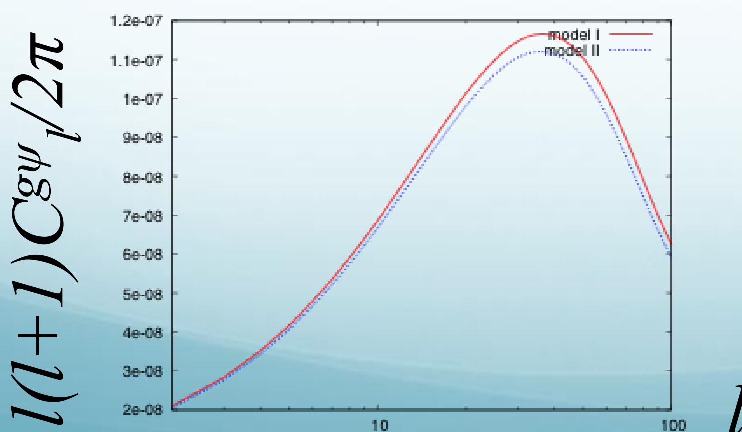
CMB × LSS cross-correlations

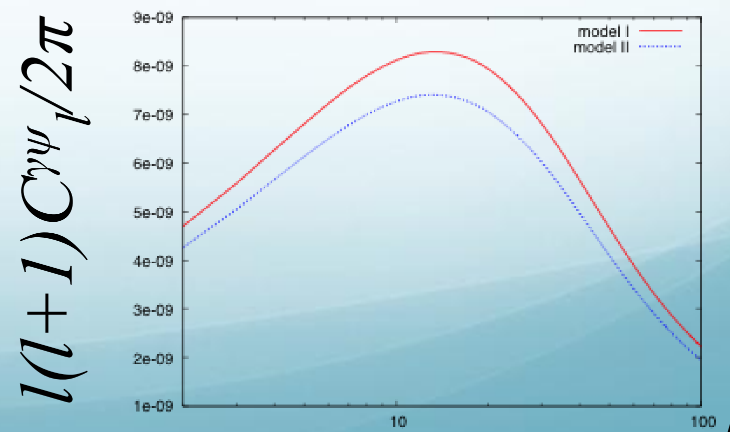
- with Temperature





- with CMB lensing potential





Constraints: CMB + LSS + SN

- Including all auto- and cross-correlations between CMB and LSS, we perform the likelihood analysis.

- Now calculating…!!
  - it takes too much time due to including all of auto- and cross-correlations.

Conclusions & Future works

- It is difficult to distinguish the models of potential for quintessence, throwing or freezing, by CMB + SN.
- The power spectra of LSS, galaxy distribution, cosmic shear and their cross-correlations, are also altered by the difference of the potentials.
- The cross-correlations between CMB and LSS may give a chance to distinguish the models of the potential quintessence.
- If the change of w(a) is important, it is worth trying the same estimation by another parameterization.
- Now, we are calculating with CMB, LSS and their cross-correlations.