Equivalence principle and cosmic background radiation

Yves Wiaux

yves.wiaux@epfl.ch

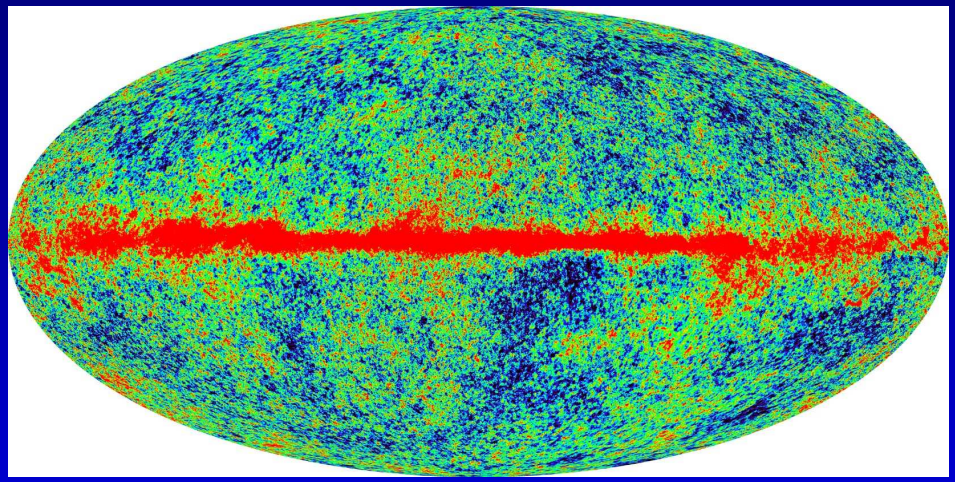
Signal Processing Institute
Swiss Federal Institute of Technology, Lausanne

Overview

Introduction

- I. Strong equivalence principle
- II. Signatures on CMB
- III. Experimental constraints and discussion

Conclusion



(Courtesy of the WMAP Science Team)

Introduction

The Cosmic Microwave Background (CMB): laboratory for precision cosmology ...

- Cosmological tests $\longrightarrow$ concordance cosmological model
  - *Spatial flatness, inflationary epoch*
  - $\Omega_\Lambda = 0.73$, $\Omega_m = 0.27$, $\Omega_b = 0.044$, ...
- Questioning underlying hypotheses
  - *Inflation, cosmological principle, universe topology*
  - *The theory of gravitation: general relativity*

... and the strong equivalence principle (SEP)

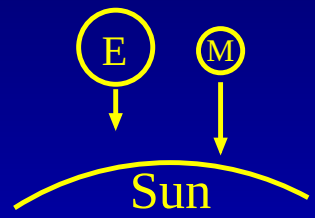
I. Strong equivalence principle

SEP violation: break down of universality of free fall for compact bodies (s)

$$T^{\mu\nu}{}_{|\nu} = G^{,\mu}\frac{\partial T}{\partial G}$$

Gravitational mass: $m_g = (1-\eta_g s)m \quad , \quad s = |E_g|/mc^2$

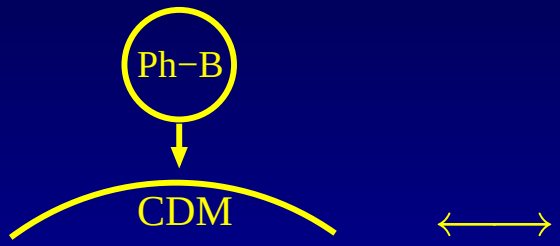
Nordtvedt effect:



- *Theoretical predictions:* $|\eta_g^{prim}| \simeq 1$
- *Experimental constraints:* $|\eta_g^{today}| < 1.3 \times 10^{-3}$

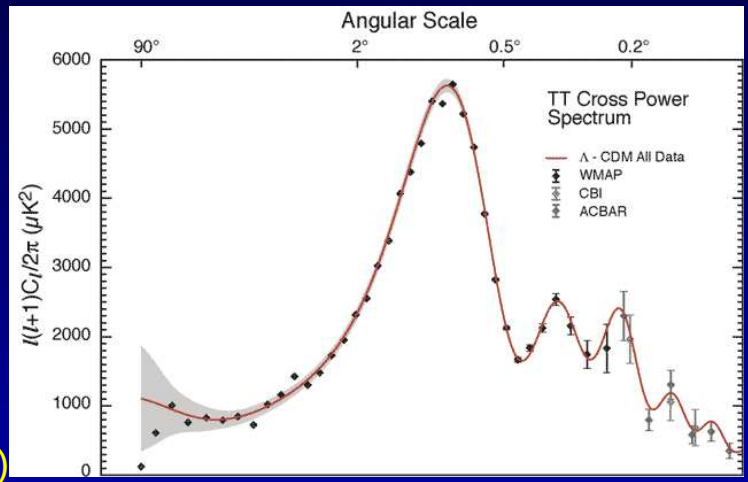
(+ PSR $J1141-6545 : |\eta_g^{today}| < 2.7 \times 10^{-4}$ *[Gérard, Wiaux 2002])*

Primordial plasma: acoustic oscillations and Gravitational coupling of baryons to CDM



$\longleftrightarrow$

(WMAPteam)



SEP violation: gravitational baryonic mass density

$$\bar{R}(s_b^n, \eta_g) = (1 - \eta_g s_b^n) R \quad , \quad s_b^{n*} \simeq 0.1 n^{-2} \quad , \quad R = 3\rho_b / 4\rho_\gamma$$

- *WMAP peaks height:*
  $\Omega_b h^2 \simeq (22 \pm 1) \times 10^{-3} \Rightarrow \bar{R}^*(s_b^{1*}, \eta_g^*)$

III. Experimental constraints and discussion

Measurement of the inertial baryonic mass density R and (suggestive) constraints on SEP violation at last scattering: η_g^* ...

- *CMB peaks location* $\Rightarrow \eta_g^* = 0 \pm 0.6$
- *Light element abundances and BBN*
  - *Deuterium* $\Rightarrow \eta_g^* = -0.3 \pm 1$
  - ^{4}*Helium and* ^{7}*Lithium* $\Rightarrow$ *explicit violation with* $\eta_g^* < 0$
- Specific alternative to general relativity
  - Precise reliable constraints in a consistent analysis
  - Running constraints towards existing bounds
- Just another way of solving the BBN - CMB discrepancy

Conclusion

to be submitted [Wiaux et al.]