INVESTIGATION OF PRIMORDIAL AND PRESENT DARK ENERGY IN THE UNIVERSE

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THE PRESENT PARADIGM OF THE EVOLUTION OF OUR UNIVERSE:

$$\cdots\cdots \rightarrow \widetilde{DS} \rightarrow FRWRD \rightarrow FRWMD \rightarrow \widetilde{DS} \cdots\cdots \rightarrow$$

t_0

$a(t)$	$e^{\int H dt}$	$t^{1/2}$	$t^{2/3}$	$e^{\int H dt}$
$H \equiv \frac{\dot{a}}{a}$	$\lvert\dot{H}\rvert \ll H^2$			$\lvert\dot{H}\rvert \ll H^2$
Main form of matter	vacuum-like (primordial dark energy)	radiation	matter	vacuum-like (present dark energy)

The central part in red: well-developed theory, definite predictions confirmed by observations

---> Some model-dependent predictions can be made, no observed effects by now

Two possible forms and interpretations of DE

1. Physical

New non-gravitational field of matter

Its proper place - in the rhs of eqn.

2. Geometrical

Depends on the Riemann tensor of our 4D or additional dimensions

Its proper place - in the lhs of eqn.

Gravity is modified

No absolute border between these 2 cases

Λ - intermediate case

Another intermediate case (but closer to geometrical DE)

non-minimally coupled scalar field

$G_{eff} \neq const$

Investigation of dark energy

I. From observations to theory

Reconstruction program (1998)

1) $H(z)$, $\varepsilon_{DE}(z)$
2) $q(z)$, $p_{DE}(z)$, $w_{DE}(z)$
3) $r(z)$, $\frac{dw_{DE}(z)}{dz}$

1. Inversion of classical cosmological tests $\mathcal{D}_L(z) \rightarrow H(z)$
2. CMB (acoustic peaks spacing, ISW), BAO
3. $\left(\frac{\delta\rho}{\rho}\right)_m(z)$, $\Phi(z)$ from gravitational lensing, correlation of $\frac{\delta\rho}{\rho}$ with CMB

II. From theory to observations

Models (many of them!)

(qualitatively — the same as for inflation)

1. Fundamental constant Λ
2. Scalar field (with $m \sim 10^{-33}$ eV, $w_{DE} \geqslant -1$)
3. Geometrical DE = modified gravity

(e.g., scalar-tensor and $f(R)$ DE models)

COLLABORATION

1. Bologna University
2. Università dell'Insubria, Como
3. INFN, Milano

RECENT PUBLICATIONS

I. dS — Primordial dark energy and inflation

1. F. Finelli, G. Marozzi, A.A.S., G. P. Vacca, G. Venturi.
Phys. Rev. D 79, 044077 (2009)
Stochastic inflation

2. A.O. Barvinsky, A. Yu. Kamenshchik, C. Kiefer, A.A.S., C. Steinwachs
JCAP 0912, 003 (2009)
Higgs inflation

II. dS — Present dark energy

1. V. Gorini, A. Yu. Kamenshchik, U. Moschella, O.F. Piattella, A.A.S.
JCAP 0802, 016 (2008)

2. V. Gorini, A. Yu. Kamenshchik,
U. Moschella, V. Pasquier, A.A.S.
Phys. Rev. D 78, 064064 (2008)

3. V. Gorini, A.Yu. Kamenshchik,
U. Moschella, O.F. Piattella, A.A.S.
Phys. Rev. D 80, 104038 (2009)

Chaplygin gas-like unified
models of dark energy and dark matter

Proposal

~1 month workshops on these
topics each year using the
BLTP, Dubna and Galileo Galilei
Institute for Theoretical Physics,
Arcetri, Firenza facilities