Cosmology and gravitation: do we need to go beyond Einstein?

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XIth RECONTRES DU VIETNAM
"Hot Topics In General Relativity and Gravitation"

Quy Nhon, Vietnam, 15.08.2015

Einstein's heritage in gravity

GR + Λ

Is it sufficient for description of all present experimental and observational evidence?

Still yes.
Note, however, the great progress in returning back Λ.

But we all are sure that this is not the final theory both in gravity and cosmology – the situation similar to that with the Standard Model of elementary particles.

Perspectives to go beyond the Einstein's heritage

No problem with theoretical models of modified gravity.
However, does Nature need any of them? Where and when to expect any breakthrough?
Unfortunately, no definite predictions can be made, only a list of the most perspective directions (which may well be incomplete).

I. Laboratory and Solar system physics.

1. Deviations from the Newton law in Cavendish-type laboratory experiments.
2. Deviation of β and γ from unity.
3. $\dot{G}/G \neq 0$.

II. Relativistic compact objects.

1. Non-Kerr "black holes" (dark compact objects without a surface).
2. Scalar gravitational radiation from double pulsars.

III. Cosmology

Here, dark matter and inflation (primordial dark energy) certainly require either going beyond the Standard Model of elementary particles, or modified gravity (cf. MOND, Higgs inflation). Present dark energy is still can be accounted by Λ.

1. Any deviation of present dark energy from Λ: $w \neq -1$, EMT anisotropy, anomalous growth of matter perturbations (it seems the most perspective to me), etc.

2. Modified gravity inflationary (or, non-inflationary) models – still not clear what would be the most crucial test of non-GR behaviour, may be $c_g \neq 1$?

Going beyond Λ

Why it is natural to expect present dark energy to be different from Λ ?

Qualitative analogy with primordial dark energy which is certainly metastable.

However, the naive application of this analogy suggests that the characteristic decay time of present dark energy should much exceed the present age of the Universe.
Still here the analogy may stop working if the effective potential required for inflation is untypical (too flat) from the point of some underlying fundamental physics – an argument proposed against inflation (I don't consider it to be serious) which I reverse into a positive one for the search of present dark energy decay.

So, it has sense to search for instability of present dark energy and, more generally, for gravitational physics beyond the Einstein's heritage!