On the one model of modified gravity

Vasilisa Nikiforova

INR RAS
Moscow, Russia

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with support of V. Rubakov (INR RAS) and S. Randjbar-Daemi (ICTP)
Modern Accelerated Expansion of the Universe

\( \Lambda \)

- problem: the value of dark energy density
- beyond \( \Lambda \)?
  - Some new physics in the Infrared (at low energies)
    - quintessence
    - ...
    - spin-2 particle instead or besides the standard graviton

Infrared Modification

\[
\frac{1}{k^2 + m^2} \quad \text{new behaviour in } k^2 \to 0 \text{ limit}
\]

Problems of massive spin-2 particle theories:

- new pathologic mode in spectrum - the ghost Boulware-Desert mode
- tachions
- there is a finite fatal difference in predictions from those of general relativity at the linear level (van Dam-Veltman-Zakharov discontinuity) - in some theories could be cured by Vainstein mechanism
The Model

The theory with Lorentz- and gauge-invariant second-order lagrangian with both vierbein $e^\mu_i$ and connection $A_{ij\mu}$ considered as independent fields.

\[ L = M_{pl}^2 R + \frac{3}{2} \tilde{\alpha} (F - R) + c_3 F_{ij} F_{ij} + c_4 F_{ij} F_{ji} + c_5 F^2 + c_6 (\epsilon \cdot F)^2 \]

$M_{pl}^2 R = L_{EH} -$ Einstein-Hilbert action;

$R = e^\mu_i e^\nu_j \left( \partial_\mu \omega_{ij\nu} - \partial_\nu \omega_{ij\mu} + \omega_{im\mu} \omega_{mj\nu} - \omega_{jm\mu} \omega_{mi\nu} \right)$

- Riemann curvature defined only by vierbein $e^\mu_i$,

$\omega_{ij\mu}$ - Riemannian connection;

$F_{ijkl} = e^\mu_k e^\nu_l \left( \partial_\mu A_{ij\nu} - \partial_\nu A_{ij\mu} + A_{im\mu} A_{mj\nu} - A_{jm\mu} A_{mi\nu} \right)$

- curvature tensor defined by connection $A_{ij\mu}$;
Linearized theory on the Minkovsky background

- All modes in linearized theory on the Minkovsky background are neither ghost nor tachyonic. 😊
- vDVZ discontinuity takes a place. Vainstein mechanism didn’t studied yet. 😞
- The interaction is mediated by both massless and massive spin-2 fields, with relative strength being a free parameter in our model - Infrared Modification. 😊
Self-accelerating solution

Field equations of the model are satisfied if one uses the ansatz in the form:

\[ e^i_\mu = \delta^i_\mu e^{-\lambda t} \rightarrow \text{it's a de Sitter metric} \]

\[ A_{ij\mu} : \]
\[ A_{0ab} = e^{-\lambda t} f \delta_{ab} \]
\[ A_{abc} = e^{-\lambda t} g \epsilon_{abc} \]

\[ f, g, \lambda = \text{const} \]

It’s a de Sitter space-time with non-zero torsion.
So, this theory has the self-accelerating space-time as a solution of its field equation. 😊
Linearized theory on the self-accelerating background

- There are no ghost Boulware-Desert mode... 😊

- Full investigation of this theory at self-accelerating background is in progress.
Thanks!
Two words about torsion

\[ A_{ijk} - A_{ikj} = T_{ijk} \] - torsion tensor

Torsion tensor equals to zero in General Relativity, because the non-zero torsion tensor breaks the equivalence principle. *The Equivalence Principle: in the gravitational field one can choose the locally inertial reference frame.*