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Supergravity with broken Lorentz invariance: theory and phenomenological consequences

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Theories with broken Lorentz invariance have attracted much attention recently. For example, a promising approach to quantization of gravity based on abandoning Lorentz invariance has been proposed by Horava. At low energies Horava gravity reduces to a special case of the so-called Einstein-aether theory - a widely studied phenomenological model, where Lorentz violation is described by a time-like vector field with unit norm ("aether") that minimally couples to gravity. However a phenomenologically acceptable theory where Lorentz invariance is not fundamental, the latter should appear at low energies as an emergent symmetry. A possible mechanism ensuring such emergence is provided by supersymmetry. We consider supersymmetric extension of the Einstein-aether theory. This cannot be realized within the minimal N=1 supergravity which does not allow to define a chiral aether vector superfield. This problem is resolved in the non-minimal formulation of the N=1 supergravity. We use the latter formulation to construct a superfield Lagrangian for the aether field coupled to linearized supergravity. We show that the constructed Lagrangian for this model is unique and obtain its bosonic part expanding in the Grassman coordinates. The model is considered also at the component level. We study supercurrent supermultiplet in the theory as an alternative way to prove its uniqueness and to construct fermionic interaction in the model. The phenomenological consequences of the model are discussed. Extension to the full non-linear Einstein-aether supergravity is also briefly outlined.

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