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# Generalizing the Cosmic Energy Equation

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(Submitted on 29 Oct 2010 (v1), last revised 19 Nov 2010 (this version, v3))

We generalize the cosmic energy equation to the case when massive particles interact via a modified gravitational potential of the form  $\phi(a, r)$ , which is allowed to explicitly depend upon the cosmological time through the expansion factor  $a(t)$ . Using the nonrelativistic approximation for particle dynamics, we derive the equation for the cosmological expansion which has the form of the Friedmann equation with a renormalized gravitational constant. The generalized Layzer-Irvine cosmic energy equation and the associated cosmic virial theorem are applied to some recently proposed modifications of the Newtonian gravitational interaction between dark-matter particles. We also draw attention to the possibility that the cosmic energy equation may be used to probe the expansion history of the universe thereby throwing light on the nature of dark matter and dark energy.

Comments: 11 pages; technical issue in the previous submission corrected; version to match publication in Phys. Rev. D [Rapid Communication]

Subjects: **Cosmology and Extragalactic Astrophysics (astro-ph.CO)**; General Relativity and Quantum Cosmology (gr-qc)

Journal reference: Phys.Rev.D82:101503,2010

DOI: [10.1103/PhysRevD.82.101503](https://doi.org/10.1103/PhysRevD.82.101503)

Cite as: [arXiv:1010.6205v3](https://arxiv.org/abs/1010.6205v3) [astro-ph.CO]

## Submission history

From: Yuri Shtanov [[view email](#)]

[v1] Fri, 29 Oct 2010 13:41:16 GMT (9kb)

[v2] Thu, 18 Nov 2010 12:09:33 GMT (11kb)

[v3] Fri, 19 Nov 2010 01:24:51 GMT (9kb)

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