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LETTER TO THE EDITOR

Quantum vacuum and dark matter

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Abstract Recently, the gravitational polarization of the quantum vacuum was proposed as alternative to the dark matter paradigm. In the present paper we consider four benchmark measurements: the universality of the central surface density of galaxy dark matter haloes, the cored dark matter haloes in dwarf spheroidal galaxies, the non-existence of dark disks in spiral galaxies and distribution of dark matter after collision of clusters of galaxies (the Bullet cluster is a famous example). Only some of these phenomena (but not all of them) can (in principle) be explained by the dark matter and the theories of modified gravity. However, we argue that the framework of the gravitational polarization of the quantum vacuum allows the understanding of the *totality* of these phenomena.

Keywords Dark matter · Antimatter · The gravitational polarization of the quantum vacuum

1 Introduction

Contemporary physics has two cornerstones: General Relativity and the Standard Model of Particle Physics. General Relativity is our best theory of gravitation. The Standard Model is a collection of Quantum Field Theories; according to the Standard Model, everything in the Universe is made from six quarks and six leptons (and their antiparticles) which interact through exchange of gauge bosons (photon for electromagnetic interactions, $W^{\pm}$ and Z^0 for weak interactions and eight gluons for strong interactions).

The problem is that our best physics is apparently insufficient to explain a series of major phenomena discovered in Astrophysics and Cosmology. One of the unexplained phenomena is that the gravitational field in the Universe is much stronger than it should be according to our theory of gravity and the existing amount of the baryonic matter (i.e. the matter composed from the Standard Model particles). This phenomenon is considered as a strong hint that at least one of cornerstones (General Relativity and Standard Model) must be significantly modified. Both approaches (modification of the fundamental law of gravity and the assumption that in addition to quarks and leptons there are still unknown fundamental particles named dark particles) have been studied by thousands of scientists, but a solution is still not at hand.

Recently (Hajdukovic 2011; but see also the first appearance of the idea in Hajdukovic 2007, 2008) a third way, without invoking dark matter and without invoking the modification of the fundamental law of gravity, has been proposed. In simple words, according to the Quantum Field Theory, all baryonic matter in the Universe is immersed in quantum vacuum; popularly speaking a "sea" of short living virtual particle-antiparticle pairs (like electron-positron pairs with the lifetime of about 10^{-22} s, or neutrino-antineutrino pairs with a lifetime of about 10^{-15} s which is a record lifetime in the quantum vacuum). It is difficult to believe that quantum vacuum does not interact gravitationally with the baryonic matter immersed in it. In spite of it, the quantum vacuum is ignored in astrophysics and cosmology; not because we are not aware of its importance but because no one has any idea what the gravitational properties of the quantum vacuum are. In absence of any knowledge, as a starting point, we have conjectured that particles and antiparticles have the gravitational charge of opposite sign. An immediate consequence is the existence of the gravitational dipoles; a virtual pair is a gravitational dipole (in

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