Astrophys Space Sci (2012) 339:7–12
DOI 10.1007/s10509-012-0994-9

LETTER TO THE EDITOR

"Dark energy" in the Local Void

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Received: 14 December 2011 / Accepted: 17 January 2012 / Published online: 26 January 2012

Abstract The unexpected discovery of the accelerated cosmic expansion in 1998 has filled the Universe with the embarrassing presence of an unidentified "dark energy", or cosmological constant, devoid of any physical meaning. While this standard cosmology seems to work well at the global level, improved knowledge of the kinematics and other properties of our extragalactic neighborhood indicates the need for a better theory. We investigate whether the recently suggested repulsive-gravity scenario can account for some of the features that are unexplained by the standard model. Through simple dynamical considerations, we find that the Local Void could host an amount of antimatter ($\sim 5 \times 10^{15}\, M_{\odot}$) roughly equivalent to the mass of a typical supercluster, thus restoring the matter-antimatter symmetry. The antigravity field produced by this "dark repulsor" can explain the anomalous motion of the Local Sheet away from the Local Void, as well as several other properties of nearby galaxies that seem to require void evacuation and structure formation much faster than expected from the standard model. At the global cosmological level, gravitational repulsion from antimatter hidden in voids can provide more than enough potential energy to drive both the cosmic expansion and its acceleration, with no need for an initial "explosion" and dark energy. Moreover, the discrete distribution of these dark repulsors, in contrast to the uniformly permeating dark energy, can also explain dark flows and other recently observed excessive inhomogeneities and anisotropies of the Universe.

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Keywords Gravitation · Cosmology: theory · Dark energy · Large-scale structure of Universe

1 Introduction

Since the end of the last century, observations of high-redshift type Ia supernovae have unexpectedly shown that the cosmic expansion is currently in an acceleration phase (e.g. Riess et al. 1998; Perlmutter et al. 1999), whose physical cause is unknown. Formally, this acceleration is ascribed to an additional term having a negative pressure in the expansion equations, which represents about 75% of the total energy density of the Universe, in the simplest case corresponding to a cosmological constant, perhaps associated to the energy of the quantum vacuum. Besides this standard cosmology of the ΛCDM model, various alternatives have been proposed to explain the cosmic speed-up, invoking scalar fields or modifications of general relativity, such as extensions to extra dimensions or higher-order curvature terms (e.g. Amendola 2000; Dvali et al. 2000; Carroll et al. 2004; Capozziello et al. 2005). In a variant of these alternative theories, Villata (2011) proposes to extend general relativity to antimatter, intended as CPT-transformed matter, whose immediate result is the prediction of a gravitational repulsion between matter and antimatter, which, with antimatter hidden in cosmic voids, could explain the accelerated expansion.

Knowledge of peculiar motions and spatial distribution of galaxies allows us to explore gravitational interactions within and among clusters. This is particularly true for our extragalactic neighborhood, where distances can be measured with higher precision. Through a study performed on a database of about 1800 galaxies within 3000 $\mathrm{km\,s^{-1}}$, Tully et al. (2008) find that the peculiar velocity of the Local Sheet