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LETTER TO THE EDITOR

On the nature of dark energy: the lattice Universe

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Abstract There is something unknown in the cosmos. Something big. Which causes the acceleration of the Universe expansion, that is perhaps the most surprising and unexpected discovery of the last decades, and thus represents one of the most pressing mysteries of the Universe. The current standard ΛCDM model uses two unknown entities to make everything fit: dark energy and dark matter, which together would constitute more than 95 % of the energy density of the Universe. A bit like saying that we have understood almost nothing, but without openly admitting it. Here we start from the recent theoretical results that come from the extension of general relativity to antimatter, through CPT symmetry. This theory predicts a mutual gravitational repulsion between matter and antimatter. Our basic assumption is that the Universe contains equal amounts of matter and antimatter, with antimatter possibly located in cosmic voids, as discussed in previous works. From this scenario we develop a simple cosmological model, from whose equations we derive the first results. While the existence of the elusive dark energy is completely replaced by gravitational repulsion, the presence of dark matter is not excluded, but not strictly required, as most of the related phenomena can also be ascribed to repulsive-gravity effects. With a matter energy density ranging from ∼5 % (baryonic matter alone, and as much antimatter) to ∼25 % of the so-called critical density, the present age of the Universe varies between about 13 and 15 Gyr. The SN Ia test is successfully passed, with residuals comparable with those of the ΛCDM model in the observed redshift range, but with a clear prediction for fainter SNe at higher z. Moreover, this model has neither horizon nor coincidence problems, and no initial singularity is requested. In conclusion, we have replaced all the tough problems of the current standard cosmology (including the matter-antimatter asymmetry) with only one question: is the gravitational interaction between matter and antimatter really repulsive as predicted by the theory and as the observation of the Universe seems to suggest? We are awaiting experimental responses.

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

1 Introduction

Since the discovery of the cosmic expansion acceleration in 1998 (e.g. Riess et al. 1998; Perlmutter et al. 1999), one of the most debated questions in physics and cosmology has been the existence and nature of the so-called dark energy, which should account for that unexpected phenomenon. Indeed, a repulsive force acting in the Universe space-time defies any previous physical knowledge, as the only known interaction among matter on these large scales is the universal Newton-Einstein gravitational attraction. Both the classical (Newtonian) and relativistic (Einsteinian) theories of gravitation seem to exclude that gravity can be in some way repulsive. However, in two recent papers Villata (2011, 2012a) showed that the general theory of relativity can be consistently extended to the existence of antimatter (which was unknown at the epoch of the birth of the two theories), based on its CPT properties, which imply that matter and antimatter are both gravitationally self-attractive, but mutually re-

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