Astrophys Space Sci (2012) 337:3–4
DOI 10.1007/s10509-011-0956-7

EDITORIAL

Editorial: Dark energy, dark matter and the quantum black hole universe

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Received: 2 December 2011 / Accepted: 2 December 2011 / Published online: 13 December 2011

For some years now, the "standard" cosmology has presented an enormous problem. Why is about 70% of the universe "dark energy", and why does there also appear to be a great deal of "dark matter", neither of which astrophysicists understand. Indeed, Brian Schmidt of the Australian National University, the latest Nobel Laureate for Physics for his discovery of dark energy describes the properties of the universe implied by his own observations of supernovae as "rather creepy".

Many papers have attempted to explain this with theory (sometimes contrived). However recently a number of papers have attempted to provide a (physically much more satisfying) explanation based upon a quantum gravity approach. Alfonso-Faus (2011) & Fullana and Alfonso-Faus (2012) in this issue of *Astrophysics & Space Science* champion the idea that the universe is a quantum black hole with entropy $\sim 10^{122} k_B$. This possibly explains the mysterious relationships between the constants of atomic physics and the constants of the Universe so often remarked upon (and for so long unexplained) by Z'eldovich, Weinberg Dirac and others—see also Hajdukovic (2010) and Dinculescu (2009).

If this idea is correct, then it implies that there is a quantum vacuum, with virtual particles flashing in and out of existence. Santos (2010, 2011) (in two papers published in *Astrophysics & Space Science*) showed that if that is the case, then the two-point correlation of the vacuum fluctuations effectively supplies a vacuum energy pressure which is of the right order of magnitude to explain dark energy!

What about dark matter? Here is where an important paper by Villata (2011) comes in. He showed that if we believe in CPT invariance, if general relativity is correct, and if anti-particles are time-reversed normal particles, as originally suggested by Feynman, then these together imply that the sign of the gravitational force between matter and antimatter is reversed (anti-gravity). In this issue, this idea is criticized, by Cabbolet (2012), and similar criticisms have been leveled by Cross (2012). However, also in this issue, Villata (2012) energetically defends his hypothesis. It may well be that these criticisms arise from the too-telegraphic nature of Villata's original paper.

If Villata's arguments are true, then it follows (Hajdukovic 2011, 2012) that placing a gravitational mass in a quantum vacuum will induce a polarization of the quantum vacuum, in the same way that a charge induces polarization in a surrounding dielectric medium. In the case of gravitation, we would expect to find more virtual particles close to a gravitating object, and more anti-particles at much greater distance. This would mean that, in a galaxy for example, the apparent gravitational attraction of the body is an increasing function of distance out to some critical value. This looks just like dark matter, as Hajdukovic has pointed out in his most recent paper. Unlike Milgrom's *Modified Newtonian Dynamics* (MOND), the distribution of vacuum polarization will depend on the distribution of matter, so the apparent extra acceleration towards the centre of mass will vary from one object to another, and as a function of position within the object. This is an idea which can be tested.

All in all, we might conclude that what is sorely needed is a true quantum gravitational theory with a quantum granulation of space-time. Within such a framework, these papers have given us grounds to hope that both dark energy

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