

Dark Energy, Dark Matter and the Accelerating Expansion of Space

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The dark energy density has been derived from the density of vacuum energy at the scale of the Bohr radius in a ten-dimensional model, and from the radius of the observable universe. The Bohr radius and the radius of the observable universe were found to be related through a 5/2 power law correspondence that applies generally between subatomic length scales and cosmological distances. It follows that dark energy is carried by ultra high frequency gravitational waves. Cosmological phase transitions of the expanding universe took place at times that correspond to specific mass, and energy, scales originating from a ten-dimensional geometry. The onset of inflation is associated with the GUT scale. Recombination has an associated particle: the electron. The accelerating expansion of space that initiated about 5 billion years ago is associated with the conjectured 7.1 keV dark matter particle, with an intriguing implication.

We have shown that dark energy is vacuum energy [1, 2, 3]. The dark energy density ρ_A on the boundary of an AdS spacetime, at the scale of the Bohr radius a_0 , is diluted from Planck scale and is given by (with $c = G = \hbar = 1$, here and throughout the analysis)

$$\rho_A = \frac{1}{2} a_0^{-5} \quad (1)$$

which has the value 1.33×10^{-123} in Planck units. This value is equal to that calculated from a fit to the Λ CDM model using WMAP9 [4] data. We then found the same value from the radius r_u of the observable universe:

$$\rho_A = r_u^{-2} \quad (2)$$

We could then write down the equation

$$r_u^2 = 2a_0^5 \quad (3)$$

which was generalised into the 10D/4D correspondence [5]:

$$t_E^2 = 2m_Q^{-5} \quad (4)$$

where t_E is the time elapsed after the Big Bang and m_Q is a mass scale. The correspondence relates cosmological distances to mass, and subatomic length, scales derived from a ten-dimensional geometry [6]. That geometry has been extensively explored: e.g. see [7, 8].

The 10D/4D correspondence relates the wavelength of the gravitational vacuum energy oscillations (dark energy) to the radius of the observable universe. The wavelength of the dark energy oscillations is equal to the Bohr radius. The frequency of the oscillations is 9.0×10^{17} Hz, i.e. they are of ultra high frequency.

Cosmological phase transitions of the expanding universe took place at times that correspond to specific mass, and energy, scales originating from the ten-dimensional geometry [5]. Mass scales assigned to the phase transitions associated with recombination, reionisation and the accelerating expansion of space are shown in Figure 1 on mass levels that derive from the geometry of the ten-dimensional spacetime [6]. Recombination is characterised by the mass of the electron. Reionisation is characterised by the Cosmic X-ray Background, peaking at 30 keV [9]. The accelerating expansion of space, which occurred about 5 billion years ago [10], is characterised by a mass scale of 7 keV and is clearly associated with Level 48.75 in Sequence 1, which is of mass 7.1 keV. This is the mass of the conjectured dark matter particle that would explain the presence of an emission line at 3.5 – 3.6 keV in inner galactic X-ray spectra [11, 12]. If the accelerating expansion of space is characterised by such a dark matter particle then we must consider the possibility that it has negative gravitational charge.

References

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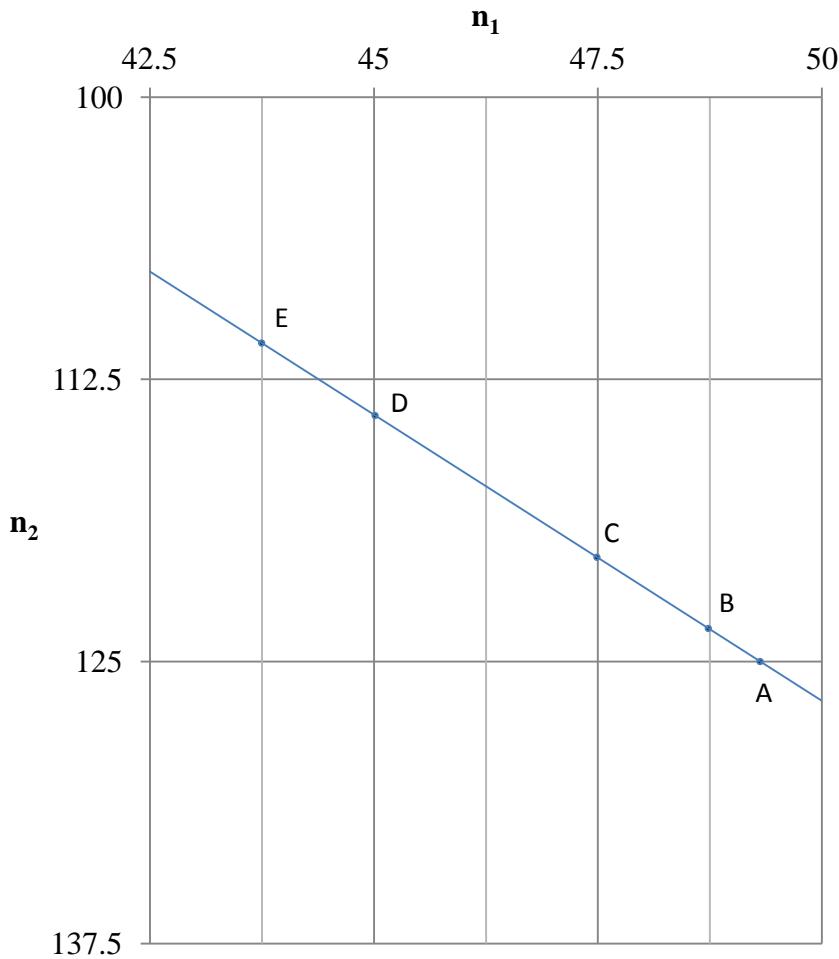


Figure 1: Mass scales on the levels of Sequences 1 and 2¹

- A. 3.73 keV, the inverse Bohr radius, corresponding to the radius of the observable universe (14,300 Mpc)
- B. 7.1 keV, the mass of the conjectured dark matter particle, corresponding to the onset of accelerating expansion (~9 billion years after the Big Bang)
- C. 30 keV, the peak energy of the Cosmic X-ray Background, corresponding to the onset of reionisation (~200 million years after the Big Bang)
- D. 0.511 MeV, the electron mass, corresponding to the onset of recombination (~240,000 years after the Big Bang)
- E. 2.2 MeV, the up quark mass

¹ Sequences 1 and 2 descend from the Planck Mass with common ratio $1/\pi$ and $2/\pi$, respectively. Level numbers in the two sequences are in constant ratio; the mass scales therefore lie on a straight line.