Review of: "On the cosmological arrow of time"

Philip Broadbridge[1]

1 La Trobe University

Potential competing interests: No potential competing interests to declare.

Review uses standard latex code:

The origin of dark energy remains a mystery, so there is room for philosophical discussions such as this one, with minimal mathematical development to illustrate a point. This one works on the radical idea of Wetterich 2013 that the observed frequency shifts are due to particle masses increasing with time, asking what is time's arrow in that scenario. There are commonly held and relevant perceptions in cosmology that are not mentioned here. Some of these I mention in comments below. There are only two listed references. I think there should be more. Cosmology might have 1000 accepted reference works. Perhaps some number like 10 might be a good start. The writing is generally good and thoughtful. Exposing some of the close-held assumptions of theoretical physics makes this a useful read for early-career researchers.\\

P1: ``concept of groundstate energy and possible tunneling between
them", change to, ``concept of energy groundstates and possible tunneling between them"\\

``either the minima V (+a) or the minima V (-a)", should use singular ``minimum" in each case.\\

P2: ``groundstate energy of the field experience(s)"\\

P3: ``In contemporary approaches, it is an assumption that the origin of dark energy is
somehow due to the energy of the groundstate fluctuations."\\
Optional: It may also be remarked that with accelerating expansion it is not even clear that a well defined vacuum state exists, consequently the fundamental scalar field may have runaway continuous energy spectrum\\
e.g. B. Allen, Phys. Rev. D 1985, 32, 3136-3149\\
e.g. P. Broadbridge and K. Deutscher, ,Symmetry 12 (6), art 943 (2020)\\

P4:`` instanton energy flow(s) from"\\

``Thermal systems tend to evolve in such a way that
[it reaches] (they reach)"\\

``The rate at which instanton energy flow(s) from"\\

{\bf Towards quantum equilibrium}\\

``If energy is conserved in the Universe,...". This is a big ``If". Through Noether's theorem, energy conservation relies on the Lagrangian density not depending explicitly on time. However your picture suggests that the two minima become closer over time so the potential has explicit time dependence $V(\psi,t)$. If the universe is expanding then a minimally coupled scalar field does evolve according to a Lagrangian with explicit time dependence so energy need not be conserved over cosmological scales\\ e.g. S. Carroll https://www.preposterousuniverse.com/blog/2010/02/22/energy-is-not-conserved/ \\
I do agree with your point though that decreasing epsilon energy gap does give a cosmological arrow of time. It is an interesting idea also that this decreases the vacuum energy fluctuations when the universe is in the neighborhood of the higher local minimum.\\

P5: ``seen as the Big Bang, where space-
time expands from a very dense and hot state, as suggested by the cosmic microwave background."--This gives a misleading impression that the CMB directly reflects the universe near the big bang. CMB escaped after significant atomic recombination, around 300,000 years after the big bang. Commonly accepted inflationary theories cover a very different universe before then, with rapid inflation over a very small time scale 10^{-35} s followed by various condensations through spontaneous symmetry breaking of unified force fields due to cooling.\\

P6: ``In both types of phases, (metaphoric) people should grow older and the (metaphoric) shattered pieces of a dropped glass of red wine should never
be witnessed to reassemble and come back to the clumsy..."--The word `metaphoric' should be inserted here as actual people and their artefacts need exist for a comparatively short time through the evolution of the universe.