A possible higher-dimensional alternative to scalar-field inflationary theory

Chad Middleton,[1,*] Bret A. Brouse Jr.,[1,†] and Scott D. Jackson[1,‡]

[1] *Department of Physical and Environmental Sciences, Colorado Mesa University, Grand Junction, Colorado 81501, USA*

We examine the time evolution of the $D = d + 4$ dimensional Einstein field equations subjected to a flat Robertson-Walker metric where the 3D and higher-dimensional scale factors are allowed to dynamically evolve at different rates. By adopting equations of state relating the 3D and higher-dimensional pressures to the density, we obtain an exact expression for the higher-dimensional scale factor as a function of the 3D scale factor. This relation allows us to write the higher-dimensional Friedmann-Robertson-Walker (FRW) field equations solely in terms of the 3D scale factor, thus yielding a set of effective 4D FRW field equations. We find the *exact* solution to these equations, which equates to the time as a function of the 3D scale factor. Two limiting regimes are found that yield series solutions for the 3D scale factor in terms of the time. The *fluid* regime solution closely mimics that described by standard 4D FRW cosmology, offering a relatively late-time behavior for the 3D scale factor after becoming valid in the early universe, and can give rise to a late-time accelerated expansion driven by vacuum energy. This is shown to be preceded by an earlier *volume* regime solution, which offers a very early-time epoch of accelerated expansion when radiation is the dominant energy component, but *only* for the unique case of $d = 1$. This volume regime solution is shown to turn on and then off, hence offering a natural entrance and exit from a possible inflationary epoch. The time scales describing these phenomena, including the transition from volume to fluid regime solution, are shown to fall within a small fraction of the first second when the fundamental constants of the theory are aligned with that of the Planck time. This model potentially offers a higher-dimensional alternative to scalar-field inflationary theory and a consistent cosmological theory, yielding a unified description of early- and late-time accelerated expansions via a 5D spacetime scenario.

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*Electronic address: chmiddle@coloradomesa.edu
†Electronic address: babrouse@mavs.coloradomesa.edu
‡Electronic address: sdjackson@mavs.coloradomesa.edu