General Relativity and Quantum Cosmology

Recessional velocities and Hubble's law in Schwarzschild-de Sitter space

David Klein, Peter Collas

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We consider a spacetime with empty Schwarzschild-de Sitter exterior and Schwarzschild-de Sitter interior metric for a spherical fluid with constant density. The fluid interior may be taken to represent a galaxy supercluster, for which the proper distance from the center of the supercluster to the cosmological horizon has the same order of magnitude as the Hubble radius derived from Friedmann-Robertson-Walker (FRW) cosmologies. The fluid interior and surrounding vacuum may also be considered as a model of the Local Group of galaxies in the far future. Particle motion is subject both to the attractive gravity exerted by the fluid and the repelling cosmological constant. Using global Fermi coordinates for the central observer within the fluid, the Fermi velocity, the astrometric velocity, the kinematic velocity, and the spectroscopic velocity, relative to the central (Fermi) observer, of a radially receding test particle are calculated and compared. We find that the Fermi relative velocity can exceed the speed of light in this model, but the presence of a positive cosmological constant causes recessional speeds of distant high energy particles to decrease rather than increase. We derive a version of Hubble's law for this spacetime which might be applicable for the analysis of a receding mass within a great void adjacent to a supercluster, relatively isolated from gravitational sources other than the supercluster. We also compare some of our results to related behavior in FRW cosmologies and consider implications to arguments regarding the expansion of space.

Comments:	This published version includes minor stylistic changes and corrections to the bibliography. The paper extends the results of, and replaces, a previous paper by the same authors entitled: "Superluminal velocities in Schwarzschild-de Sitter space," arXiv:0910.5254v1
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