

General Relativistic Shock Waves that Induce Cosmic Acceleration

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A family of global shock-wave solutions of the Einstein field equations for a perfect fluid are constructed. These shock-wave solutions consist of an interior self-similar expanding wave and an exterior self-similar static wave, separated by a spherical shock surface. The interior and exterior fluids are assumed to have isothermal equations of state of the form $p = \sigma \rho$ and $\bar{p} = \bar{\sigma} \bar{\rho}$ respectively, with the strictly positive constants σ and $\bar{\sigma}$ representing a single parameter for each wave. The interior wave has an additional parameter, denoted by a , which represents how perturbed this wave is from a Friedmann-Lemaître-Robertson-Walker spacetime with the same equation of state. The joining of the interior and exterior waves forms a shock-wave solution when mass and momentum are conserved across the shock surface, which places a constraint on the three parameters. The resulting shock-wave solution is thus a two-parameter family of solutions. For $\sigma = \bar{\sigma}$, the two-parameter family becomes a one-parameter family and such solutions model the general relativistic version of an explosion within a static, singular, isothermal sphere. Interestingly, the two-parameter family of shock waves solve the Einstein field equations in the absence of a cosmological constant, but despite this, a cosmic acceleration is still present in the interior wave, with the acceleration parameterised by a . This fact follows from the pioneering work of Smoller and Temple. The presence of this acceleration in the absence of a cosmological constant opens up the question of whether a vast primordial shock-wave could give rise to the cosmic acceleration observed today without the need for dark energy.

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