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Absence of Curvature Singularities in Symmetric Perfect Fluid Spacetimes in Einstein-Gauss-Bonnet Gravity

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We investigate higher-dimensional homogeneous and isotropic perfect fluid spacetimes within the framework of Einstein–Gauss–Bonnet (EGB) gravity. By solving the modified field equations, which include higher-order curvature corrections, we derive evolution equations for the scale factor and show that it admits a strictly positive minimum value. This lower bound depends on the spacetime dimension N, the coupling parameter α, and the chosen equation of state. Crucially, this behavior eliminates the possibility of curvature singularities that occur when the scale factor vanishes, such as those found in Big Bang or Big Crunch scenarios.

We demonstrate that this regular behavior is universal across all physically reasonable perfect fluid equations of state, both linear (e.g., radiation or dust-like matter) and nonlinear (e.g., generalized Chaplygin gas). This suggests that singularity theorems can be bypassed in EGB gravity without violating energy conditions. Furthermore, the appearance of a bounce in the collapsing region implies the potential formation of regular black holes, preventing the central singularity via higher-dimensional geometric effects.

In our analysis, we identify N=9 as a critical dimension, where the minimum scale factor reaches its peak for fixed α, indicating maximum repulsive effect from Gauss–Bonnet corrections. Numerical analysis and plots support this claim, emphasizing the influence of dimensionality on the avoidance of singularities. These findings underscore EGB gravity as a viable model for constructing non-singular cosmologies and regular gravitational collapse scenarios.

Keywords: FLRW spacetimes, Einstein–Gauss–Bonnet gravity, curvature singularities, bouncing cosmologies, higher dimensions

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