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A Directive for obtaining Algebraically General Solutions of Einstein's Equations

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Algebraically general solutions in General Relativity are notably rare and less mathematically tractable compared to their algebraically special counterparts. Nevertheless, this kind of solutions is quite interesting in mathematical and physical point of view.
In a previous study conducted in vacuum with cosmological constant under the framework of Newman-Penrose formalism, we explored an analytical solution extraction technique assuming the existence of canonical Killing tensor forms combined with a general null tetrad transformation. This led us only to algebraically special solutions encompassing Petrov types D, III, and N. In this regard, a Petrov type D solution emerges, describing a general family of cosmological models which are topological products of two-dimensional spaces with constant curvature.

In the present work, we extend this approach by introducing a specific class of Lorentz transformations. Under the same initial assumptions, this leads to a new algebraically general solution featuring a curvature singularity. This result also raises new questions regarding the role and preferability of specific transformations in the solution extraction process.

These findings suggest a new directive in solution extraction: the assumption of canonical Killing tensor forms, combined with special Lorentz transformations in the context of symmetric null tetrads, provides new and broader classes of algebraically general solutions of Einstein's equations.

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