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Framework for nonlocally-related PDE systems and nonlocal symmetries: Algorithmic approach

For a given PDE system, one can construct extended hierarchies ("trees") of nonlocally-related PDE systems. Each system in an extended tree is equivalent, in the sense that the solution set for any system in a tree can be found from the solution set for any other system in the tree. Due to the equivalence of solution sets, any coordinate-independent method of analysis (qualitative, numerical, perturbation, *etc.*) can be applied to any system within the tree, and may yield simpler computations and new results that cannot be obtained when the method is directly applied to the given system. Nonlocal symmetries and new local and nonlocal conservation laws for a given PDE system can arise from any system in its extended tree.

The concept of useful conservation laws plays an essential role in the construction of an extended tree. Useful conservation laws yield potential variables and equivalent nonlocally-related potential systems and subsystems for any given system.

We construct extended trees for the systems of Planar Gas Dynamics and Nonlinear Telegraph equations. Using the described framework, we demonstrate a direct relation between Eulerian and Lagrangian descriptions of gas dynamics, and find new families of conservation laws and new nonlocal symmetries.

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