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Construction and Applications of Nonlocally Related Systems of Partial Differential Equations

For a given Partial Differential Equation (PDE) or a system of PDEs, with $n \geq 2$ independent variables, I will describe a systematic (and rather general) framework to find PDE systems *nonlocally related* to the given one. Such nonlocally related PDE systems have solution sets that are equivalent to the solution set of the given system (i.e., any solution of a nonlocally related system yields a solution of the given system, and, conversely, any solution of the given system yields a solution of the nonlocally related system). Moreover, the solution of any boundary value problem posed for the given PDE system is embedded in the solution of a boundary value problem posed for the nonlocally related (*potential*) system (and the converse also holds).

Due to nonlocal relations and the equivalence of solution sets, any general method of analysis (symmetry, conservation law, qualitative, perturbation, numerical, etc.), when applied to one of such nonlocally related PDE systems, can yield new results. In particular, new conservation laws, nonlocal symmetries and new exact solutions have been found for many nonlinear PDE systems arising in applications.

I will discuss several illustrative examples: the Nonlinear Wave equation, Planar Gas Dynamics equations, equations of Nonlinear Elastodynamics, and Plasma Equilibrium equations in 3D.

The talk is aimed at the broad audience of applied mathematicians and researchers working with PDE models.

This is a joint work with George Bluman.