A generalized midpoint-based boundary-value method for unstable PDEs

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We present a boundary-value method (BVM) that can be used for partial differential equation (PDE) models having semi-stable, unstable or even ill-posed, properties. Traditionally, step-by-step methods, such as Runge-Kutta and linear multistep methods, are used for time-dependent models. However, their numerical stability regions (this holds for all explicit and implicit methods) are such that a significant part does not intersect with areas in the complex plane which are of importance for a stable time-integration of unstable DEs. BVMs, that need extra numerical conditions at the final time, are global methods and are, in some sense, free of such barriers. As an example, BVMs based on generalized midpoint methods combined with appropriate numerical initial and final conditions, possess the whole complex plane (excluding the imaginary axis) as stability region. On the other hand, obviously they loose some efficiency, since an extended linear or nonlinear system has to be solved for the whole time range of interest. We will illustrate the usefulness of such methods for several PDE models, such as a dispersive wave equation, a space-fractional PDE and the backward heat equation.