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**Jacobian-Free Newton-Krylov Methods for the Accurate
Time Integration of Stiff Wave Systems**

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Stiff wave systems are systems which exhibit a slow dynamical time scale while possessing fast wave phenomena. The physical effects of this fast wave may be important to the system, but resolving the fast time scale may not be required. When simulating such phenomena one would like to use time steps on the order of the dynamical scale for time integration. Historically, Semi-Implicit (SI) methods have been developed to step over the stiff wave time scale in a stable fashion. However, SI methods require some linearization and time splitting, and both of these can produce additional time integration errors. In this presentation, the concept of using SI methods as preconditioners to Jacobian-Free Newton-Krylov (JFNK) methods is developed. This algorithmic approach results in an implicitly balanced method (no linearization or time splitting). We provide an overview of SI methods in a variety of applications, and a brief background on JFNK methods. We will present details of our new algorithmic approach. Finally, we provide an overview of results coming from problems in geophysical fluid dynamics (GFD) and magnetohydrodynamics (MHD).