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Chemora: A Scalable PDE Solving Framework for Modern HPC Architectures

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Modern HPC architectures consist of heterogeneous multi-core many-node systems with deep memory hierarchies. Modern applications continue to employ advanced discretisation methods to study multi-physics problems. Developing such applications that explore cutting-edge physics on cutting-edge HPC systems has become a complex task that requires significant HPC knowledge and experience.

Chemora is a generic framework for solving systems of Partial Differential Equations (PDEs) that targets modern HPC architectures. Chemora is based on Cactus, which sees prominent usage in the general relativistic astrophysics community. PDEs are expressed either in a high-level latex-like language or in Mathematica. Discretisation stencils are defined separately from equations, and discretisation can include Finite Differences, Discontinuous Galerkin Finite Elements, Adaptive Mesh Refinement (AMR), and multi-block systems.

We use Chemora in the Einstein Toolkit to implement the Einstein Equations on CPUs and on accelerators, and study astrophysical systems such as black hole binaries, neutron stars, and core-collapse supernovae.