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Minimal ℓ^2 Norm Discrete Multiplier Method

Many dynamical systems possess multiple conserved quantities and preserving such quantities are fundamental for accurate long-term simulations. Well-known examples include energy and momentum for physical systems, but time-dependent conserved quantities may also exist for dissipative systems. Unfortunately, traditional integrators do not in general preserve such quantities, leading to recent developments on general conservative integrators, such as Discrete Gradient Method or Discrete Multiplier Method (DMM). While both approaches can lead to systematic derivation of conservative integrators, they can be difficult to apply in practice for large systems with multiple conserved quantities.

To alleviate such practical difficulty, we introduce the Minimal ℓ^2 Norm Discrete Multiplier Method (MN-DMM) to extend the practical applicability of DMM, where conservative schemes are constructed procedurally. In essence, MN-DMM utilizes a Moore-Penrose pseudoinverse of the discrete multiplier matrix leading to a unique consistent conservative scheme with the minimal ℓ^2 norm via a suitable fixed point iteration. We show the wide applicability of MN-DMM and its relative ease of implementation on various examples.

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