A High Order Non-Splitting Conservative Semi-Lagrangian Discontinuous Galerkin Method for the Two-Dimensional Transport Simulations

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In this talk, we will introduce a high order non-splitting conservative semi-Lagrangian (SL) discontinuous Galerkin (DG) method for the two-dimensional transport simulations. The proposed method relies on a characteristic Galerkin weak formulation and a high order characteristics tracing mechanism. Unlike many existing SL methods, the high order accuracy and mass conservation of the method are realized in a non-splitting manner. Thus, the detrimental splitting error, which could significantly contaminate long term transport simulations, will be not incurred. One key ingredient in the scheme formulation is the use of Green's theorem which allows us to convert volume integrals into a set of line integrals. The resulting line integrals are much easier to approximate with high order accuracy, hence facilitating the implementation. The desired positivity-preserving property is further attained by incorporating a high order bound-preserving filter. To assess the numerical performance, we benchmark the proposed SLDG schemes for simulating several transport problems, the nonlinear Vlasov-Poisson system and incompressible flow. The efficiency and efficacy of the proposed scheme are numerically verified when compared with other prominent transport solvers such as the Eulerian DG methods combined with Runge-Kutta time integrators.