INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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This thesis is devoted to the development of numerical frameworks for ideal magneto-hydrodynamics (MHD) based on the finite volume and meshfree approaches. The principal contribution is a new flux-splitting scheme based on wave-particle behaviour for solving compressible ideal MHD equations in one and two dimensions. This scheme referred to as Magneto-acoustic Wave-Particle Splitting (MWPS) scheme splits the flux vector into three distinct parts: the particle-like transport part and the wave-like pressure and magnetic parts. This tripartite treatment of the total flux vector results in a scheme with a central-upwind like character and has been extended to second-order spatial accuracy through the solution-dependent weighted least-squares approach for gradient calculations in one-dimension and by employing a limited linear reconstruction scheme with Venkatakrishnan limiter in two-dimensions. The solenoidality constraint of magnetic field in two-dimensions is satisfied by employing the Artificicial Compressibility Analogy (ACA) approach together with a dual time-stepping method. The finite volume solver is tested on several benchmark problems in one and two dimensions, the latter using both structured and unstructured grids. The numerical results show that while the MWPS scheme is at least as accurate as the AUSM (Advection Upstream Splitting Method) and the CRH (Central Rankine-Hugoniot) schemes and even outperforms them in some challenging scenarios. The development of a one-dimensional MHD solver in a meshfree framework using the Upwind Least-Squares based Finite Difference (LSFD-U) method is also explored in this thesis. Meshless solvers do not satisfy the discrete conservation property, in general. We propose a set of criteria to obtain a conservative meshfree framework and show that the use of inverse-distance weights with a “symmetric” stencil could fulfill these criteria thereby leading to a discretely conservative scheme on any arbitrary distribution of points. Numerical experiments on different MHD problems and arbitrary point distributions lend evidence in support of the arguments and result in a conservative meshfree solver for one-dimensional ideal MHD. The developments, both on the finite volume and meshfree fronts, discussed in the thesis points to an indigenous, accurate and robust numerical framework for simulations of compressible ideal MHD flows.