On the convexity of relativistic ideal magnetohydrodynamics and the associated gravitational wave emission

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ABSTRACT

This work has been done in collaboration with J. M. Ibáñez, N. Sanchis-Gual, J.A. Font, M.A. Aloy, J.M. Martí, J.A. Miralles and A. Marquina. We analyze the influence of the relativistic effects and magnetic field in the convexity properties of the relativistic magnetohydrodynamics system of equations. To this purpose we use the approach of Lax, based on the analysis of the linearly degenerate / genuinely nonlinear nature of the characteristic fields. The non-relativistic, unmagnetized limits are properly recovered. The characteristic fields corresponding to the material and Alfvén waves are linearly degenerate and, then, not affected by the convexity issue. The analysis of the characteristic fields associated with the magnetosonic waves reveals, however, a dependence of the convexity condition on the magnetic field. The result is expressed in the form of a generalized fundamental derivative written as the sum of two terms [1]. The first one is the generalized fundamental derivative in the case of purely hydrodynamical (relativistic) flow [2]. The second one contains the effects of the magnetic field, and generalizes the non-relativistic magnetic case [3]. To illustrate the influence of the relativistic effects encoded in the first term, we present some numerical simulations using an EoS for which the sound speed is non-monotonous, which implies that the fundamental derivative can be negative and the EoS non-convex. Non-convex fluid dynamics can yield to the development of unusual wave structures such as rarefaction-shocks and compound waves. We use a non-convex phenomenological EoS to evolve a rotating star as a toy model and compute the gravitational wave emission.

References

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