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VERIFICATION OF AN HYPERSONIC FLOW SOLVER USING DISCONTINUOUS MANUFACTURED SOLUTIONS

Juan P. Saldía[a] **and Sergio A. Elaskar**[a,b]

[a]*Departamento de Aeronáutica, Facultad de Ciencias Exactas, Físicas y Naturales (FCEFyN), Universidad Nacional de Córdoba (UNC), Argentina*

[b]*Instituto de Estudios Avanzados en Ingeniería y Tecnología (IDIT) FCEFyN-UNC/CONICET, http://www.inv.idit.efn.uncor.edu*

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Abstract. The method of manufactured solutions (MMS) is a widely used technique applied to the verification of computational software for the numerical modeling of physical systems, that is, the process by which certainty that the numerical algorithms of the model are correctly implemented is obtained. In the MMS, the original governing equations of the model are modified through the introduction of an analytically derived source term, such that the numerical solution of the modified model converges to a prescribed manufactured solution. When applied to mesh-based computational mechanics codes, the MMS generally introduces the requirement of a volumetric integration of an analytical expression at the mesh element level. The usage of discontinuous manufactured solutions in the MMS, required for the verification of numerical models where discontinuities naturally arise, has been addressed only in few works. Previous efforts in this direction, have focused only on particular cases in two dimensional domains, or when the manufactured solution is simple enough to allow the computation of exact integrals through symbolic manipulation engines. In the present work, we have applied recent techniques for the high-order numerical integration of discontinuous solutions introduced in T-P. Fries et.al., Int J Num Meth Eng, 106:323-371 (2015), to the MMS based verification process of an in-house second order finite volume solver with shock-capturing schemes for the numerical simulation of hypersonic thermochemical non-equilibrium flows. A high-order reconstruction of a level set based implicit description of the discontinuity surface is first obtained, serving as the basis for the volumetric integration of the additional source terms introduced by the MMS, on those elements crossed by discontinuities. A generic framework has been implemented for the employment of this technique in unstructured mesh discretizations of both 2D and 3D computational domains. Finally, results regarding the MMS verification process that has been carried out are obtained and discussed.