A multi-material HLLC Riemann solver with both elastic and plastic waves for 1D elastic-plastic flows

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Abstract

A multi-material HLLC-type approximate Riemann solver with both elastic and plastic waves (MHLLCEP) is constructed for 1D elastic-plastic flows with the hypo-elastic model and the von Mises yielding condition. Although Cheng in 2016 **?** introduced a HLLC Riemann solver with elastic waves(HLLCE) for 1D elastic-plastic flows, Cheng assumed that pressure is continuous across the contact wave. This assumption maybe lead to big errors, especially for multi-material elastic-plastic flows. In our MHLLCEP, this assumption is not used again, and correspondingly the errors introduced by the assumption are deleted, describing and evaluating the plastic waves are more accurate than that in the HLLCE. Moreover, if the non-linear waves in the Riemann problem are only shock waves, even with the plastic waves, our MHLLCEP is theoretically accurate. For the multi-material system, in this paper, a ghost cell method is used to achieve high-order spatial reconstruction across the interface without numerical oscillations. Based on the MHLLCEP, combining with the third-order WENO reconstruction method and the third-order Runge-Kutta method in time, a high-order cell-centered Lagrangian scheme for 1D multi-material elastic-plastic flows is built in this paper. A number of numerical experiments are carried out. Numerical results show that the presented third-order scheme is convergent, robust, and essentially non-oscillatory. Moreover, for multi-material elastic-plastic flows, the scheme with the MHLLCEP is more accurate and reasonable in resolving the multi-material interface than the scheme with the HLLCE.

Keywords: HLLC Riemann solver, high-order cell-centered Lagrangian scheme, WENO scheme, hypo-elastic model, elastic-plastic flows

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