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基于HLL-HLLC的高阶WENO格式及其应用研究

High order WENO scheme based on HLL-HLLC solver and its application

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中文关键词： 五阶WENO格式 四阶中心差分格式 HLLC 高分辨率格式 可压缩流动

英文关键词:5th-order WENO scheme 4th-order central differencing scheme HLLC high resolution scheme compressible flow

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中文摘要:

HLL-HLLC格式能够克服HLLC在强激波附近的激波不稳定现象，并且保持了HLLC的低耗散特性，是一种适合更大马赫数范围的近似黎曼求解器。本文从RANS方程出发，将HLL-HLLC近似黎曼求解器结合五阶WENO重构，实现了对无粘通量的高阶离散；同时，采用完全守恒形式的四阶中心差分格式处理粘性项，建立了RANS 方程的高阶数值求解格式。通过对四个经典算例，钝头体、 ONERA M6机翼、DLR F6-WB翼身组合体和DLR F6-WBNP复杂外形的数值模拟，考察了两种WENO改进格式在复杂流场中的表现，研究了高阶格式的收敛特性；给出了在复杂流动中 WENO自由参数的推荐值，以增强求解的收敛性。算例结果表明，本文构造的高阶格式鲁棒性好，能够显著改善激波位置和激波强度，捕获更丰富的流场细节，满足复杂工程应用需求。

英文摘要:

HLL-HLLC is one kind of schemes which are suitable for a large range of Ma number.It can overcome the shock instability phenomena which may happen to HLLC scheme while keeping low dissipation.The proposed HLL-HLLC scheme is coupled with finite difference type of high order WENO schemes based on characteristic variables to evaluate the inviscid numerical flux in a high order.Meanwhile,a set of fully conservative 4th-order central difference schemes are utilized to deal with the viscous terms.In this way,high order numerical methodologies for RANS are established.Four classical test cases are simulated to validate the proposed schemes:hypersonic flow over blunt body、transonic flow over ONERA M6 wing、transonic flow over DLR F6-WB configuration and DLR F6-WBNP complex configuration.The performances of two WENO variations are investigated.What's more,the free parameter for WENO schemes is proposed in complex fluid simulations to strengthen the convergence rate.Numerical results show that:high order schemes could capture the shock sharply and give a more accurate location of strong shocks; furthermore,much more flow details could be distinguished.The proposed high order schemes are robust enough to satisfy the needs of engineering.

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