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近空间高超声速流场通量分裂型DSMC-IP方法

Flux splitting DSMC-IP method in near space hypersonic flow field

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中文关键词： 近空间 高超声速 直接模拟蒙特卡洛-信息保存(DSMC-IP)方法 Van Leer格式 流场

英文关键词:near space hypersonic direct simulation Monte Carlo-information preserve(DSMC-IP) method Van Leer scheme flow field

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中文摘要:

针对近空间高超声速流场的特点,采用Van Leer格式对直接模拟蒙特卡洛-信息保存(DSMC-IP)方法质量守恒方程中的计算格式进行改进.将局部马赫数作为分裂通量的标准,并重构单元分界面两侧的左右输运通量,使得计算格式具有通量分裂的特点,解决了DSMC-IP方法在高超声速流场计算中的应用问题.将改进后的通量分裂型DSMC-IP方法引入非结构网格中,对二维近空间高超声速流场进行数值模拟.计算结果表明:通量分裂型DSMC-IP方法所得出的数值结果与实验值及参考值符合较好,明显降低了直接模拟蒙特卡洛(DSMC)方法所带来的统计耗散.当来流气体的稀薄程度增加时,其非平衡效应也更加明显,而通量分裂型DSMC-IP方法的计算结果与参考值相差均在10%以内,良好地反映了非平衡条件下的流场特征,验证了通量分裂型DSMC-IP方法的可行性和有效性.

英文摘要:

According to the characteristics of the hypersonic flow field in near space, the computational format of the mass equation of direct simulation Monte Carlo-information preserve (DSMC-IP) method was improved by the Van Leer scheme. The local Mach number was set as the standard of the flux splitting, and the transport fluxes on both sides of the cell interfaces were reconstructed. So the computational format has the characteristic of the flux splitting, and the application problems of the DSMC-IP method in hypersonic flow field were solved. The two-dimensional hypersonic flow field in near space was simulated by the improved flux splitting DSMC-IP method with unstructured grid. The solution of computation by the flux splitting DSMC-IP method has good agreement with the results of experiment and reference value, and the statistics dissipation of direct simulation Monte Carlo (DSMC) method was reduced significantly. When the flow becomes more rarefied, the non-equilibrium effect becomes more obvious. In this situation the results of flux splitting DSMC-IP method differs within 10% from the reference values, so the characteristic of the flow field is well reflected in non-equilibrium situation. The results prove the feasibility and validity of the flux splitting DSMC-IP method.

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