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密度非对称的二维无碰撞磁场重联

黄俊[1],马志为[2]

1 中国科学院基础等离子体物理重点实验室,中国科学技术大学,合肥 230026;2 浙江大学聚变理论与模拟中心,杭州 310027

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摘要　使用二维粒子模拟（PIC）的方法研究了在电流片两侧具有不同温度或密度情况下的无碰撞磁场重联过程.在初始等离子体密度非对称的情况下，发现重联区等离子体流场结构、电磁场结构以及重联过程与对称情况下的结果有明显不同.通过对电流片两侧温度比取不同的参数$T_m/T_s=1,2,5$进行模拟(其中T_m和T_s分别代表磁层侧和磁鞘侧的温度),结果分析发现,(1)在密度非对称系统中，出流区电子沿着分离面出现一个整体的从高密度区向低密度区的流动，并围绕磁岛形成一个电流环；(2)在高温低密度一侧，在重联过程中，分离面两侧将出现很强的电荷分离并产生一个基本垂直于分离面的强度较大的电场E_z，其幅度和空间尺度与温度梯度近似地成线性正比和反比关系.在初始电流片两侧温度之比取$T_m/T_s=5$的情况下，E_z的幅度将达到0.71，其空间尺度与局地电子惯性长度d_e同一量级，这一结果与观测相吻合；(3)重联率随着温度梯度增大而下降.

关键词　磁层顶　无碰撞磁场重联　粒子模拟　非对称电流片　温度梯度　重联率　垂直电场
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Two-dimensional collisionless magnetic reconnection with initial asymmetric density distribution

HUANG Jun[1], MA Zhi-Wei[2]

1 CAS Key Laboratory of Basic Plasma Physics, School of Science, University of Science and Technology of China, Hefei 230026, China;2 Institute for Fusion Theory and Simulation, Zhejiang University, Hangzhou, Zhejiang 310027, China

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Abstract Collisionless magnetic reconnections with different initial temperature gradients across the current sheet are studied through two-dimensional Darwin Particle-in-cell simulations. Due to asymmetric properties of the temperature and density, it is found that the plasma flow, electric field, and magnetic field structures as well as the reconnection dynamical process exhibit significant differences from that in the symmetric case. Through the case studies, the results can be concluded: （1） In the asymmetric cases, electrons drift from the high density region to the low density region, which leads to form a current loop along the saperatrix in out-flow region; （2） Intense charge separation appears near the edge of the magnetic island in the high temperature and low density region and results in a large perpendicular electric field structure. The amplitude and the scale of the electric field are linearly proportional and inverse to the temperature gradient, respectively, For the case $T_m/T_s=5$, where T_m and T_s represent the temperature in magnetospheric side and magnetosheath side respectively, the amplitude of E_z will be 0.71 and the scope is of the same order of the electron inertial length d_e, which are in good agreement with the observations; （3） the reconnection rate will decrease with increase of the temperature ratio.

Key words Magnetopause; Collisionless magnetic reconnection; PIC simulation; Asymmetric current sheet; Temperature gradient; Reconnection rate; Perpendicular electric fiel

通讯作者:
黄俊 jhuang1207@yahoo.com.cn
作者个人主页: 黄俊[1];马志为[2]