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论文

环电流区中性原子观测特性模拟研究

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摘要: 为了给双星计划中性原子(ENA)探测仪的研制提供可靠的理论依据, 并为未来中性原子探测数据的分析及研究做好准备, 针对双星轨道初步模拟计算了双星 ENA探测仪对磁暴时中性原子的观测特性. 建立了磁暴主相期间环电流离子分布的一个近似理论模式, 并模拟计算了极轨卫星在极区上空、赤道面以及其他位置上对不同强度磁暴主相期间环电流区ENA空间角分布及能谱的观测结果. 研究表明, 存在环电流区方向和南北极区环电流粒子沉降带两个中性原子强度极大区域; 磁暴越强烈, 注入区高度越低, 环电流区观测到的ENA通量越高; 处于有利位置的ENA探测器可分辨注入区内边界或注入前沿; ENA探测器能够分辨环电流带离子分布的不均匀性; 由于离子交换截面的差异, H, O, He 3种ENA的能谱分布不同; 在10~80keV能谱范围内通量较强, 易于观测; 环电流区H, O两种ENA通量较强, 有利于观测; 而环电流区He ENA通量很弱, 不易于观测. 模拟计算研究表明, 双星极轨卫星能够对环电流区ENA进行有效探测; 低纬轨道上的ENA探测器也能够对环电流区ENA进行一些观测; ENA探测器的研制应重视低、中能量范围ENA的探测.

关键词: 中性原子成像 卫星探测 磁暴 粒子注入 环电流离子分布 电荷交换反应

ENERGETIC NEUTRAL ATOM IMAGING OF THE EARTH'S RING CURRENT REGION

扩展功能

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Abstract: A simulation investigation has been carried out on the observed properties of energetic neutral atoms (ENA) during geomagnetic storm main phase in order to provide reliable theoretical foundations for the development of ENA detector on board the polar satellite of Double Star Program (DSP) of China and also make preparation for the future ENA observation data analyses. In this research, an approximate analytical model for the ring current particle distribution including the ion loss due to charge exchange has been developed. The simulation shows that there are two maximum ENA flux regions, i.e., the ring current inner boundary region and particle precipitation region at the northern and southern poles. The stronger the storm is the lower the particle injection is and the larger flux of ENA is emitted from the ring current region. The ENA detector at advantageous positions can measure the inner boundary of the injection region or the injection front. The ENA detector is able to measure the inhomogeneity of the ring current ions. The features of the energy fluxes of H, O and He are different with each other due to the discrepancy of their charge exchange cross sections. The ENA at 10~80keV are easier to be observed owe to the large fluxes. ENA H and O are easier to be measured because of their stronger fluxes. On the contrast, ENA He is more difficult to be detected due to its rather weak flux. This simulation research has indicated that the polar satellite of DSP is capable of detecting

the ring current ENA. The ENA detector at low latitudes, e.g. , on board the equatorial satellite, is also useful for observing the ring current ENA. More importance should be stressed on the detectability for low and mid energy ENA during the development of the ENA detection on board the polar satellite of DSP.

Keywords: Energetic neutral atom imaging
Satellite exploration Magnetic storms
Particle injection Ring current ion distribution
Charge exchange.