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智利地震前DEMETER卫星对空间高能粒子的观测

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DEMETER satellite observations of energetic particle prior to Chile earthquake

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摘要

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摘要 在地震的孕育或发生期间,地球内部岩石圈的活动可能会发出电磁辐射,引起空间电磁扰动,并通过波粒相互作用引起高能电子的投掷角散射,导致高能电子的沉降.本文基于法国DEMETER卫星的观测数据,研究了智利周围区域在智利地震期间空间高能电子的通量、能谱的分布及演化,发现在智利地震发生前第11天和12天,在以震中为中心,经度跨度 10° ,在DEMETER卫星轨道高度上 L 跨度0.1的区域内,有超出背景4到6倍的高能带电粒子暴的出现,期间在其北半球磁镜像区域也观测到了显著的电子通量增高.粒子暴对应的能谱与2010年前三个月的平均能谱存在较大差异.同时观测到在出现粒子暴的两条轨道上VLF(Very Low Frequency,甚低频)电场频谱分别在300 Hz以下以及13~20 kHz的频段存在显著增强,此扰动在时间和地理位置上与高能粒子暴是一致的.基于回旋共振耦合作用的准线性扩散理论,本文对所观测事例的电子能量与电磁场扰动频率做了分析计算.观测数据和理论计算有较好的一致性,表明该粒子暴源自ICE(Instrument Champ Electrique,电磁探测器)观测到的空间电磁扰动,这是典型的空间波粒耦合事例.进一步分析排除了可能引起粒子暴和VLF电场扰动的环境因素,本文认为本次粒子暴和电场扰动的观测可能与智利地震的震前地壳活动存在一定关联.

关键词 DEMETER卫星, 高能带电粒子暴, VLF电场扰动, 智利地震, 波粒回旋共振耦合

Abstract: The lithosphere activity during seismogenic process or occurrence of one earthquake may emit electromagnetic waves which propagate to ionosphere and radiation belt, then induce disturbance of electric and magnetic field and the precipitation of high energy charged particles induced by pitch angle scattering from interaction of wave and particle. This paper, based on the data detected by DEMETER satellite, presents the high energy charged particle burst (PB) with 4 to 6 times enhancement over the average value observed about ten days before Chile earthquake in the center of epicenter within longitude 10 degrees and Mc Ilwain L 0.1. The obvious particle burst was also observed in the northern hemisphere mirror points conjugate of epicenter. The energy spectra of the PBs are different from average value within the first three months in 2010. At the same time, the disturbance of the VLF electric spectrum under 300 Hz and in 13~20 kHz frequency band in ionosphere over the epicenter detected by the DEMETER satellite are also observed in the same two orbits. Finally we calculated the coupling relation between the energy of PBs and frequency range of VLF electric spectrum disturbance by wave and particle cyclotron resonant interaction, then obtained the consistent result of observation and theoretical calculation. It is indicated that the PBs are indeed caused by VLF electromagnetic wave in ionosphere possibly transmitted from earth's surface or lithosphere, which is a typical wave and particle coupling event. Eliminating the possible origin of PBs including magnetic burst and solar activities, we think the PBs and VLF electric spectrum disturbance are likely to have a certain link with Chile earthquake.

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