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电离层人工调制在水平分层电离层中所激发的ELF波辐射

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Radiation of ELF waves by ionospheric artificial modulation into a stratified ionosphere

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摘要

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摘要 通过大功率ELF/VLF调幅高频波能有效地扰动低电离层,形成等效的ELF/VLF电离层虚拟天线,用来辐射ELF/VLF波,所辐射出的低频信号可以进入中性大气层形成地球-电离层波导.本文基于调制加热模型,采用全波有限元算法计算由人工调制电离层所形成的电偶极矩所辐射出的ELF波在水平分层电离层中的波场,计算结果将与地面观测结果进行比较.模拟结果表明,所辐射出的ELF波在电离层中形成一个窄的准直波束,海面所能接收到的ELF信号强度为pT量级,并且频率越低,海面所接收到的场强就越小,与HAARP实验数据一致.结果还表明,低纬电离层对低频信号的传播衰减较大,并且所能透射出电离层的角度小,因此高纬地区更适合地球-电离层波导的激发.

关键词 电离层人工调制, ELF波, 全波解, 数值模拟, HAARP实验

Abstract: Using powerful high-frequency radio waves modulated at ELF/VLF can efficiently modify the lower ionosphere which can act as an equivalent ELF/VLF virtual antenna for the generation of ELF/VLF waves which can propagate in the Earth-ionosphere waveguide. In this paper, based on the modulation model, a full-wave finite element method is used to calculate the field of the ELF waves radiated by the dipole moment which is produced by ionospheric artificial modulation in the stratified ionosphere and the calculated values are compared to the ground observation. The numerical modeling shows that these waves form a narrow collimated beam and the magnitude of field intensity of low frequency signals received on the sea is ~pT which will become smaller when the frequency is lower and this result is in accordance with the laboratory data from HAARP. The result also shows that it has stronger attenuation and small angle penetrating the ionosphere for the low signal at low latitude, so that the excitation of the Earth-ionosphere waveguide is easier at high latitude.

Keywords Ionospheric artificial modulation, ELF waves, Full wave method, Numerical simulation, HAARP experiment

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