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Artificial Aurora and Ionospheric Heating by HAARP

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Abstract

A recent experiment was achieved at HAARP to study the scaling of the ionospherically generated ELF signal with power transmitted from the high frequency (HF) array. The results were in excellent agreement with computer simulations. The outcomes approving that the ELF power increases with the square of the incident HF power. This paper present a review on the situation of the ionized particles in Ionospheric layer when stimulated by artificial an ELF and VLF external high energy radio waves.

Keywords: Ionospheric modification, Ionospheric heating

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1 Introduction

Near the ground the air is almost unionized and its electrical conductivity is negligibly small. In very near equilibrium atmosphere, gravity force has a powerful controlling effect up to about 1000 km from the ground [1]. The gradient of the refractive index is responsible for the bending of the propagation direction of the electromagnetic wave [2]. If it is negative, the signal bends downward. In stable meteorological conditions a trajectory can form near the surface of the sea, acting as a wave guide in which high frequency radio waves can propagate to great distances [3, 4, 5, 6]. In this paper we reviwe the situation of the ionized particles in Ionospheric layer when stimulated by artificial an Extremely Low Frequencies (ELF), Very Low Frequencies (VLF) external high energy radio waves, the Earths ionosphere, ionospheric plasma, Ionospheric radio wave propagation and HAARP ionospheric heating in brief. The final conclusion shows a result of a simulated HAARP time-varying current perturbation (1 kHz) in the D-region at 75 km.

2 Ionospheric plasma and plasma oscillations

The ionosphere is divided into three layers D, E and F. The lower level of Ionosphere (D) is situated normally from 50 km to 90 km. This layer does not reflects HF radio waves but is mainly responsible for their absorption, particularly at lower frequencies. The E layer is the next higher in altitude. It is from 90 km to 120 km approximately and only reflects radio waves with a frequency lower than 10 MHz and partially absorbs higher frequencies. The D and E region consist mainly of NO^+, O^{+2} ions and electrons. The next layer is F and ranges from 120 km to 400 km above the Earth surface. During the day, it divides into two layers, called F1 and F2. It is responsible for most of sky wave radio propagation. The F1 layer is located from 180 to 200 km and is absent at night. The F2 region peaks around 250 to 300 km. The F region consists mainly of O^+, NO^+, N^+ and electrons. Temperature and plasma density in terms of altitude shown in the Fig (1). By modulating the ambient current flowing in the ionosphere, for example, the auroral electrojet, it is possible to generate extremely low frequency (ELF) and very low frequency (VLF) radiation [7]. An ionospheric heater or an ionospheric HF pump facility is a powerful radio wave transmitter with an array of antennas which is used for research of plasma turbulence, the ionosphere and upper atmosphere [8]. The first evidence of modification of the ionosphere by radio waves was reported by Tellegen (1933) [8, 9]. The heating can excite new plasma oscillations [10] and enhance those already present in atmosphere. This process strongly influences the propagation of the EM pump wave in the perturbed region and causes large decreasing in the reflected wave, refer as anomalous absorption and scattering.

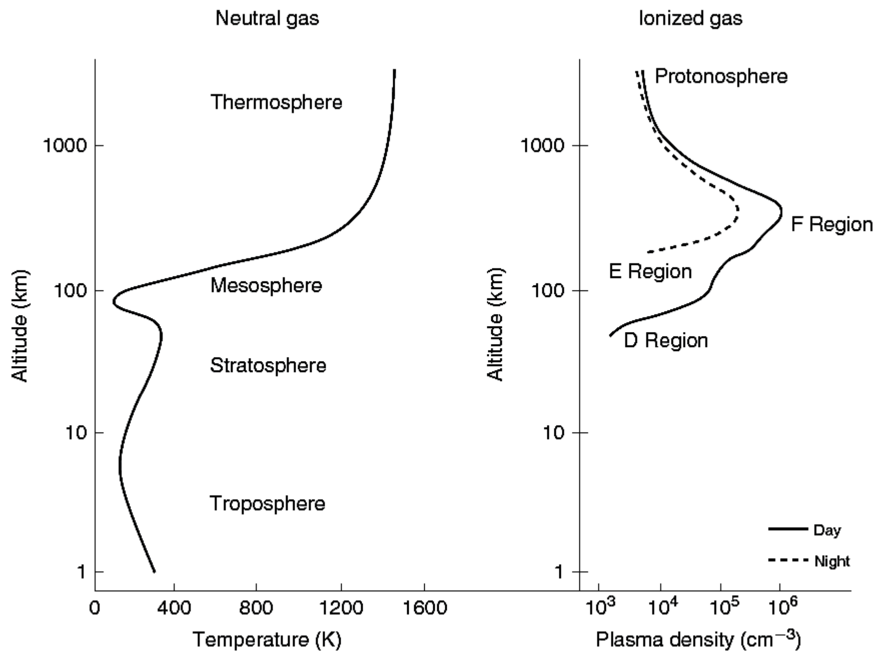

Figure 1: Temperature and plasma density in terms of altitude for neutral and ionized gases in atmosphere of Earth.

The heating of the F-region ionosphere, the high power EM wave modifies the interaction region near the reflection height by increasing both the local electron temperature and reducing the local plasma density[11, 12].

3 Ionospheric Radio Wave Propagation and HAARP

Travelling of radio waves from a transmitter to a receiver near the earth's surface, take in several possible paths. [13]. As a specific example, we consider the propagation of radio waves through the Earths ionosphere. The refractive index of the ionosphere can be written as

$$n^2 = 1 - \frac{\omega_p^2}{\omega(\omega + i\nu)}. \tag{1}$$

where ν is the collision frequency of free electrons with other particles in the ionosphere and ω_p is the plasma frequency as

$$\omega_p = \sqrt{\frac{Ne^2}{\varepsilon_0 m}}. \tag{2}$$

Here N is the density of free electrons in the ionosphere, and m is the mass of electron. We assume that $N = N(z)$, and z measures height above the Earths surface. In typical day-time number density of free electrons in the E-layer is about $N \sim 3 \times 10^{11} m^3$ while at night-time, the density of free electrons falls to about half this number. Therefore the typical day-time plasma frequency of the E-layer is about 5 MHz. The typical collision frequency of free electrons in the E-layer is about 0.05 MHz. Accordingly any radio wave whose frequency lies below the day-time plasma frequency, 5 MHz, is reflected by the ionosphere during the day. We note that, $\nu \ll \omega$ for mega-Hertz frequency radio waves.[14]. Since radio waves can travel or propagated from one point to another or into different parts of the atmosphere [15], therefore thses radio signals can show various effects. The important effects not only are into the atmosphere of the Earths but also have many effects on the surfacemof the Earth and also in the deepest depths of our oceans such as, earthquakes, Cyclones and strong localized heating [16]. One of the most well known experiments is HAARP program that we consider in the next section. The observations have been shown that anomalies of radio wave propagation in VLF, LF, HF, and VHF bands before strong earthquakes are associated with ionosphere modification by the precipitating particles in increased ionization in the D-layer of the ionosphere [17]. The High-Frequency Active Auroral Research Program (HAARP) facility located in Gakona, Alaska AK (62^oN, 145^oW) is the worlds largest heating facility, yielding effective radiated powers in the gigawatt range [18, 19, 20, 21, 22]. HAARP is able to transmit between 2.8 to 10 MHz up to 3.6 MW total power [18]. One of the goals of these HAARP experiments is the generation electrostatic waves in the ionosphere [18]. Much of the research at the facility is focused on the generation of ELF/VLF because of the value of these frequencies to the Navy for undersea applications [23]. HAARP heats our ionosphere with shooting high-frequency signals into space spiraling along the field-lines of our magnetosphere where they are amplified and return to Earth. Ionospheric Heater (IH), or in other word Sky Heater (SK), is a powerful HF transmitter that induces controlled temporary modification to the electron temperature at specific altitude. This process is the same as for the aurora. In fact an ionospheric heater is an array of antennas which are used for heating the ionosphere, and which can create artificial aurora. Heater antenna arrays pump electricity from the ground into space. Current HF pump facilities are as ; European Incoherent Scatter Scientific Association (EISCAT) in Norway with transmitting 1.2 MW or over 1 GW, Space Plasma Exploration by Active Radar (SPEAR) (with transmitting 192 kW or 28 MW ERP) , Sura ionospheric heating facility in Vasilsursk near Nizhniy Novgorod in Russia (with transmitting 750 kW or 190 MW ERP), High frequency Active Auroral Research Program (HAARP) north of Gakona, Alaska (with transmitting 3.6 MW or 4 GW ERP) and High Power Auroral Stimulation Observatory HIPAS

Observatory northeast of Fairbanks, Alaska (with 1.2 MW or 70 MW ERP). The Figures (2) show HAARP simulation which has taken from Navy-Mil [**?**] and show the time variation (T-V) for 1100 ns current perturbation of 1 kHz in the D-region of Earths Ionosphere at 75 km. The Earths magnetic field is vertical and this simulation cover for 120 km.

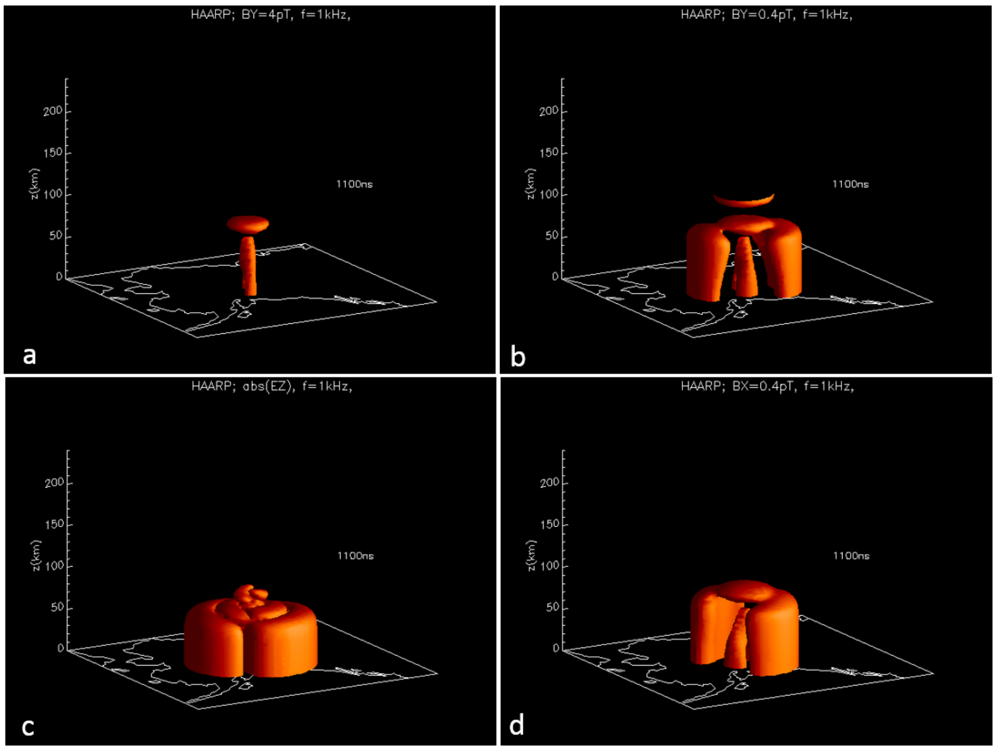

Figure 2: Time-varying current perturbation (1 kHz) in the D-region at 75 km. The Earth's magnetic field is vertical. This simulation cover for 120 km. (a) HAARP :BY 4 pt, f = 1 kHz , 1100 ns, (b) HAARP :BY 0.4 pt, f = 1 kHz , 1100 ns, (c) HAARP :abs (EZ) 0.4 pt, f = 1 kHz , 1100ns,(d) HAARP :BX 0.4 pt, f = 1 kHz , 1100 ns.

4 Conclusion

Ionospheric heating facilities creating global warming and its modification by powerful HF waves transmitted from the ground show different aspects. If the frequency of the signa1 is increased the virtua1 height increases more rapid1y than the true height. When the level of the maximum electron density in the layer is reached the virtual height becomes infinite. This frequency usually is called the critical frequency of the layer. Another important effect of the propagation of a radio signal is the double refraction due to the interaction between the electrons in the plasma and the magnetic field. The two waves reflected independently in the ionosphere, known as magnetoionic components, are called, by analogy with optical double reflection, the ordinary and the extraordinary wave. By controlling the ionospheric heating in high-altitude, electric currents forming such as the auroral electrojet and midlatitude dynamo currents. Therefore it is possible by modulating the auroral electrojet, to make Extremely Low Frequency (ELF) and Very Low Frequency (VLF) radiation. These rays of energy could then potentially be reflected back into the Earth's ionosphere on an extremely low frequency, as ELF waves.

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