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Grach, C.M.[1]; Sergeev, E.N.[1,2]; Bakhmetieva, N.V.[2];Milikh, G.[3]; Shindin, A.V.[1]
1. Lobachevsky State University of Nizhni Novgorod, Russia
2. Radiophysical Research institute, Nizhni Novgorod, Russia
3. University of Maryland, College Park, USA

Preliminary Results of the Artificial Periodic Irregularities Excited by the HAARP HF Heater

Abstract:
First results on the ionospheric sensing by the resonant scattering of HF radio waves by the Artificial Periodic Irregularities (APIs) are presented. The experiments were carried out at the HAARP heating facility (62.65 N; 145.25 W) in May and June, 2014. Currently, regular studies of this phenomenon are carried out at the SURA heating facility (56.15 N; 46.11 E). The results of these studies and the theory of the API are summarized in the monograph (Belikovich V.V. et al. Ionospheric Research by Means of Artificial Periodic Irregularities – Copernicus GmbH, 2002. Katlenburg-Lindau, Germany, 160 pp.). The APIs are formed by a standing wave that occurs due to interference between the propagating upward radio waves and that reflected from the ionosphere. The reflection is due either to the ponderomotive force that develops near the wave reflection point in the F region of the ionosphere, or to the electron heating in the D and E regions of the lower ionosphere, that occurred in the antinodes of the standing wave. The processes responsible for the API formation and relaxation (after the incident wave turns off) are excitation and decay of the ion sound wave in the F-region, ambipolar diffusion in the E-region and temperature dependence of the electron attachment rate to the oxygen molecules during three-body collisions in the D-region. API studies are based on the observation of the Bragg backscattering of the probe radio waves. Sounding probe radio pulses are radiated during the API relaxation stage; amplitudes and phases of scattered pulse signals are measured. In the HAARP experiment, the processes of both API development and decay were studied. For this the HAARP facility operated with periodicity of 15(30) s. This period consisted of (i) 70 ms pulses separated by 30-ms pauses and short (20 μs) sounding pulsed during first 3 (10) s, and (ii) 20 μs sounding pulses with IPP 20 ms during the following 12 (20) s. The pulse train (i) used for study of the API development and stationary states, while the train (ii) used for the relaxation stage. The X-polarization of the heating and sounding modes was applied. The experiment was carried out from May, 30 till June, 5, 2014 at 19 - 24 UT. During the experiment with the heating frequencies 4.1, 5.1 and 5.925 MHz, the APIs were observed in the D-region (occasionally), E- and F-regions. A weak scattering on the API in the sporadic-E layer were also detected. API scattered signals at the HAARP were similar to those at the SURA. Characteristic times of the API rise and relaxation in the E-region amounted 1-1.5 s, which corresponds to the API theory. The API technique allowed to obtain such parameters of the lower ionosphere as the neutral temperature and density, vertical plasma velocity, electron density, ion composition of the sporadic-E layer, the lower boundary of the region enriched by the atomic oxygen.

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