URSI GASS 2021, Rome, Italy, 28 August - 4 September 2021

First results of the HF heating campaign EISCAT-Ukraine on June 2020

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We report on the results obtained during the June 23-26, 2020 experiments at the EISCAT heating facility aimed to: 1) explore artificial ionospheric turbulence (AIT) and stimulated electromagnetic emissions (SEE) during transmissions near the 3rd electron gyroharmonic and upper hybrid resonance; 2) search for artificial ionospheric layers; 3) explore the effects of powerful HF signals propagation on radio lines of different lengths, including long distance paths. We used the EISCAT UHF incoherent scatter radar (ISR), EISCAT broadband HF receiver, and dynasonde. HF receivers of the Institute of Radio Astronomy NAS of Ukraine (IRA NASU) recorded radio emission of the heater at several spatially separated positions located in the Arctic (two-channel receivers in Tromso and at Svalbard), Ukraine (three-position system near Kharkiv), and in Antarctic (two-channel receiver at the Ukrainian Antarctic Station (UAS) *Akademik Vernadsky*).

Some evidence of the generation of artificial ionospheric layers is seen in a raw ISR data. We detected several cases of splitting of the heights of intense interaction of the pump wave with the ionospheric plasma in the ion line spectra. In different heating cycles the height difference between two maxima of the spectral power ranged from 10 to 40 km. The maximum height separation is usually observed in the frequency range 4.10 - 4.17 MHz at the pump frequency close to the double resonance, $3f_{ce} \approx f_{uhr}$. Within the same heater frequency range, we also detected some resonant features at the frequencies of the downshifted maximum (DM) of the SEE spectra recorded by the EISCAT broadband HF receiver. Another effect observed by two HF receivers located near the heater was an additional spectral peak downshifted by 10 Hz to 20 Hz from the pump frequency. This spectral maximum appears only at the initial stage of heating and then disappeared in 1 to 5 seconds.

In the course of the campaign, we studied the possibility of feeding the ionospheric waveguide by the transmitted wave scattered on artificially stimulated plasma irregularities. In particular, one experiment was aimed at comparing the effects of heating at O and X polarizations. It is known that at moderate powers O-mode heating is much more efficient than X-mode. During the experiment, this difference was confirmed by the ISR data. Further analysis concerns the comparison of the pump signal propagation along a quasi-vertical radio path (heater-Tromso) and long-distance radio path (heater-UAS). For the quasi-vertical path, the intensity of the X polarized signal reflected from the ionosphere was greater than the O-mode, likely because some part of the O-mode power supported heating. The O-mode intensity along the long-distance radio line exceeded the X-mode level. The inverse difference between signal intensities at O and X polarizations in Antarctica can be explained by propagation of the heater signal from the northern to the southern hemisphere in the raised ionospheric waveguide fed by the scattering of the pump wave on the heater induced irregularities, efficiently excited only by the O-mode heating.

We are very grateful to the EISCAT staff for supporting operation of the heating facility and ISR during the campaign.