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Investigations of the HAARP Radiation Propagating along the Super Long Radio Paths (review)

Abstract:
HAARP facility is an unique research instrument, which can be used for investigations of the interaction between high-power electromagnetic waves and ionospheric plasma as well as for studies of propagation effects on the long-distant HF radio paths. Observations of the HAARP signals at several geographically dispersed radio sites are carried out by the Institute of Radio Astronomy, National Academy of Sciences of Ukraine (IRA NASU) for about ten years. They are performed using the network of digital HF receivers developed by the IRA NASU team. The access to the data and remote control by the acquisition systems are implemented via the Internet network. In this study we will discuss results collected at the observational sites located near Kharkov (Ukraine), Tromsø and Svalbard (Norway), and at the Ukrainian Antarctic Station (UAS, Antarctic Peninsula, 65.25 S, 64.25 W). The results of data processing show that the heater signal simultaneously recorded at several spaced observation points can be used to study the "self-scattering" of the ionospheric irregularities produced by the same HF pumped wave. This effect was first observed for the EISCAT heater at sites located, near Kharkiv, St. Petersburg and at UAS. High level of correlation of the temporal variations of the self-scattered spectra at different sites was detected. The observations of HAARP signal were used to calculate relaxation and rise times for the self-scattered signals. The average relaxation times were shown to be several tens of seconds (40-60 s), while the observed rise time was much longer, up to a few minutes. The power and spectral width of the scattered signals depends on the HAARP beam orientation and local ionospheric conditions. Another effect, which is discussed here, is the enhancement of the HAARP signal detected at UAS located 15.6 Mm from the heater. The possible explanation of this effect is propagation of the HAARP signal in the ionospheric interlayer waveguide. This effect was commonly observed when the solar terminator passed simultaneously over the transmitting and receiving sites. The regular gradients of the electron density appears in the ionosphere during the solar terminator passage near the observer can be responsible for signal output from the interlayer waveguide. The exaltation of the waveguide may be produced by wave scattering on the artificial or natural ionospheric plasma irregularities. In both cases, area of the ionosphere near the heating facility will provide the dominant contribution to the variations of spectra parameters recorded at UAS, because propagation in the interlayer waveguide occurs with small losses and minimal spectral distortions. This effect was confirmed by the detected correlations between the variations of Doppler frequency shift observed at UAS and D component of the geomagnetic field measured by the HAARP magnetometer. A clear correlation of the signal intensity recorded at UAS with the amplitude of downshifted SEE maximum and its anticorrelation with the strength of broad upshifted SEE maximum observed near HAARP were detected.