#87 Received 01/20/2015

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Stimulated Plasma Emission at the Second Harmonic of the Pump Wave

Abstract:
The possibility of generating of the electromagnetic radiation at harmonics of the pump wave in the ionospheric plasma is still open because of complexity of the experiments on its detection. The fact is that the parasitic generation of harmonics can occur in the output circuit of the transmitter, and separate it technically from the possible ionospheric effects is very difficult. To solve the problem of selection the second harmonic excited in the ionosphere the special scheme of the experiment has been implemented. It based on using the stable low-power probe wave on the frequency near the second harmonic of the pump wave for inspecting the propagation conditions of parasitic radiation. The conclusion about generation of the second harmonic in the ionosphere was done by comparing of its parameters with the probe signal. Two special measuring campaigns organized jointly by the Institute of Radio Astronomy, National Academy of Sciences of Ukraine (IRA NASU), and EISCAT Scientific Association were held on 29-31 October 2013 and 17-18 November 2014. During the campaigns the EISCAT heating facility and UHF incoherent scatter radar, as well as IRA NASU coherent HF receiving systems located in Tromsø, Svalbard (Norway), and Kharkov region (Ukraine) were used. At the time of experiments, the carrier frequency of the pump wave was constant and equal to 3989942 Hz. Additionally the heater radiated the probe pulse signal with power of about 100 kW at carrier frequency upshifted on 500 Hz from the second harmonic of the pump frequency. The level and frequency of the probe signal during the measurement remained constant. The pump, probe, and second harmonic waves were recorded in all receiving sites. At the time of effective interaction between the pump wave and the plasma (according to the data of EISCAT UHF incoherent scatter radar) on October 31, 2013 and November 17, 2014 the signal at the second harmonic of the pump wave has been observed in Tromsø at the significantly higher level in comparison with the probe signal. At the other receiving sites the second harmonic of the pump wave has not been registered. Ratio between the levels of second harmonic and probe signal in Tromsø grew up on 50 dB during the effective interaction of the pump wave with the ionosphere, and it was equal to zero in the absence of interaction. The second harmonic has been observed for both "O" and "X" polarizations of pump wave. The strong dependence of the second harmonic parameters on the conditions of the interaction between pump wave and ionospheric plasma, and the absence of its correlation with the parameters of the probe signal indicate that the second harmonic of pump wave is generated in the ionosphere.