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Artificial periodic irregularities in the lower ionosphere, atmospheric waves and sporadic E-layer

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The long-term researches have shown that artificial periodic irregularities (API) created in the ionosphere plasma are a good means for the ionosphere diagnostics. In the report we present the new applications of the API technique for experimental studies of the lower ionosphere, atmospheric waves and sporadic E-layers. The applications are based on the new so-called two-frequency method of the API creation for the ionosphere diagnostic. The main results of the ionosphere studies carried out in 2006–2009 by the API technique using SURA heating facility are presented.

API are formed in the field of a powerful standing radio wave produced by interference of the incident wave and reflected one by the ionosphere (Belikovich et al., Ionospheric Research by Means of Artificial Periodic Irregularities-Katlenburg-Lindau, Germany. 2002. Copernicus GmbH. ISBN 3-936586-03-9). The spatial period of the irregular structure is equal to the standing wavelength or the one-half the power wavelength $\lambda/2$. Ionosphere diagnostic is carried out in the API relaxation stage by their sounding of probing radio pulses.

The two frequency method bases upon the API creation and the scattering of the probe waves from API at two different frequencies that is having different spatial periods of the quasi periodic structure. In the E-region of the ionosphere API are formed as a result of the diffusion redistribution of the ionosphere plasma. Relaxation of the periodic structure is specified by the ambipolar diffusion process. The API relaxation time depends on the power wavelength and the ambipolar diffusion rate. It means that API having different spatial scales destroys with different time scales τ. The API spatial scale depends on the refractive index n that is determined by the electron density N. It is shown the ratio of API relaxation times θ at two frequencies f_1 and f_2, measured at the same heights, is connected with the frequencies ratio and the refractive index ratio. The measurement of the $\theta(h)$ dependence makes it possible to determine electron density profile $N(h)$. The profile is used for determination of the neutral temperature and density, the turbulent velocity and also the sporadic E-layer parameters (Belikovich V.V. *Radiophys. Quantum Electron.,* 2006, Vol. 49, No. 9).

Vertical velocity was determined by measuring the phase of the probe radio waves scattered from API after switching off the power heating facility, i.e., at the API relaxation stage. The velocity and N(h) data have been used for estimation the total density metallic ions and the effective recombination rate at the sporadic E-layer maximum. The measured vertical velocity shift was about $5{\cdot}10^{-3}$–10^{-4} c^{-1}. The shift can be caused by acoustic gravity waves and is sufficient for collecting of metal ions in sporadic E-layer.