Popular-scientific description of the project

From the moment James Clerk Maxwell (1867) theoretically unified the electric and magnetic interactions, it became clear that electromagnetic waves existed. Already several years after the publication of the theory of electromagnetism, these waves were discovered by Henrich Hertz (1888), which resulted in the invention of radio (Marconi, 1895) and other methods of communication using electromagnetic waves in the long wave spectrum, commonly known as radio waves. Extremely important in the process of transmitting information using modulated radio waves is a good knowledge of the phenomena occurring during propagation from the transmitter to the receiver. Such research has been conducted since the beginning of the 20th century and led to the discovery that astrophysical objects in natural physical processes can generate radio waves. They were first observed by Karl Jansky in the 1930s.

Although Gauss postulated the existence of electric charges and currents in the atmosphere in the 1830s, it was only in the 20th century that it became clear that there was a layer that effectively reflects long radio waves, which phenomena was carefully used in trans-ocean telecommunications. The very word ionosphere and research related to it is already the domain of the late 1920s and 1930s, when the existence of this layer in the atmosphere at a height of about 50 km (D layer) up to even 500 km (F2 layer) was confirmed. In 1947, Edward Appleton was awarded the Nobel Prize for confirming the existence of the ionosphere.

The close relationship between electromagnetic waves, in particular in the radio range, and electric charges is well known in physics, and carries over to the influence of the ionosphere (and other electrically charged areas) on the propagation of these waves. The matter becomes important because the ionosphere is an extremely dynamic area, constantly moderated by various factors (mainly solar activity). In the era of satellite communication, the trans-ionospheric propagation of waves is hence constantly modulated by the phenomenon of wave bending at the medium boundary, (which gives characteristic scintillations in time domain). The same phenomena affect radio waves that reach the Earth from astrophysical sources, with changes taking place not only in the ionosphere itself, but also in the interstellar regions of ionized gases.

Figure. Observations of radio scintillation in the layers of the ionosphere can be compared to the image of distorted light at the bottom of a body of water after passing through water

LOFAR is an instrument working in the ranges of radio wavelengths, which undergo significant deflection in the ionosphere, and in addition is extremely sensitive, which makes this instrument an excellent tool for comparative studies related to the dynamics and modeling of the ionosphere.

In our research project, we will observe the state of the ionosphere using the LOFAR radio telescope as a space objects' wave detector from, the GNSS observatories system and other techniques for probing the state of the ionosphere at low and ultra low frequencies. As a result of our activities, we want to significantly improve the models of radio wave propagation in a wide frequency range through areas of an ionized medium, such as the ionosphere.