Physics experiment in Earth's atmosphere could help improve GPS performance

October 27 2021

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The Earth's atmosphere has been used as a 'laboratory' to carry out a physics experiment, in research collaboration involving the University of Strathclyde which could help to improve the performance of GPS.

The study displays a new method of remotely monitoring the plasma in the ionosphere and of controlling wave modes in a way which could help GPS make better calculations in the face of extreme space weather.

The researchers conducted a controlled radar wave experiment by injecting radio waves into the ionosphere, at slightly different frequencies.

The returned signal was then recorded and analyzed. The researchers found that plasma waves were excited in the ionosphere and non-linear waves were mixed, leading to a wide spectrum of non-linear frequencies in the returned signal.

Plasma in the ionosphere plays a significant role in reflecting and modifying radio waves used for communication and radio navigation systems such as GPS, but the accuracy of these can be affected by 'space weather' events such as solar storms.

The experiment was carried out at the EISCAT facility near Tromsø, Norway and the research has been published in the journal *Nature Communications.*

Dr. Bengt Eliasson, a Reader in Strathclyde's Department of Physics, was a partner in the research and said: "The Ionosphere is part of Earth's upper atmosphere, between 80 and about 1000 km, where extreme ultraviolet and X-ray solar radiation ionizes atoms and molecules, creating a layer of plasma.

"Other phenomena, such as energetic charged particles and cosmic rays, also have an ionizing effect and can contribute to the ionospheric plasma density.

"The discovery of the Earth's ionosphere came from early radio wave

observations more than a century ago, and the recognition that only a reflecting layer composed of electrons and ions could explain the observations. Early research was aimed at explaining the various layers in the ionosphere and their variability through factors such as local time, latitude and season.

"Today, the emphasis of ionospheric research has shifted toward understanding the dynamics and plasma physics of ionospheric phenomena, particularly due to disturbances driven by the sun, known as space weather events. These space weather events dynamically increase the total number of ionospheric electrons; GPS systems cannot correctly model this dynamic enhancement and errors occur in position calculations.

"The active control of the wave modes excited in the ionosphere, described in our article, has the potential of providing new and improved diagnostics of temperature, density, magnetic field and ion composition, with the potential of improving GPS position calculations during times of disturbance."

More information: B. Eliasson et al, Controlled beat-wave Brillouin scattering in the ionosphere, *Nature Communications* (2021). DOI: 10.1038/s41467-021-26305-9

Provided by University of Strathclyde, Glasgow