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The problem of radio wave propagation through plasma density irregularities in the ionosphere: a discussion on recent modelling challenges

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Radio waves that traverse the Earth's ionosphere can propagate through inhomogeneities in the spatial distribution of the plasma density. These inhomogeneities (or irregularities) deform the wavefront, thus inducing constructive and destructive interference with the propagation distance. A particular situation occurs when these irregularities drift across the ray path: the received radio waves manifest a stochastic temporal pattern, known as radio wave scintillation.

Radio wave scintillation is the result of the scattering of wavefronts from inhomogeneities in the spatial distribution of the refractive index, which is related to the ionospheric electron density via the Appleton-Hartree model. Whilst irregularities are related to various formation mechanisms, they are typically modelled by invoking a random spatial distribution across ray paths.

Radio wave scintillation gives rise to higher-order propagation effects that manifest in various fields: satellite navigation, Earth Observation (e.g., synthetic aperture radars), radio astronomy. These higher-order effects can become dominant at times, thus suggesting the need for more advancement in the modelling of this particular propagation problem. In turn, a more precise description of the problem enables the use of radio wave scintillation to sense a given propagation medium, hence providing information about inhomogeneities and formation mechanisms taking place in a given plasma.

This contribution will discuss examples of radio wave scintillation and its effects in domains such as satellite navigation, radio receivers' demodulation and tracking, radio astronomy. It will describe challenges in the modelling of the propagation problem as well as recent advancements in the understanding of details of the propagation problem (e.g., in relation to the distribution of irregularities).