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Investigating the Fresnel scale from ionospheric scintillation spectra

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Trans-ionospheric radio signals recorded on the ground exhibit random amplitude and phase fluctuations attributed to irregularities in the ionospheric electron density. Studying ground-based measurements of these radio signals can significantly contribute to understanding plasma instability mechanisms responsible for creating these ionospheric structures. In this regard, radio signals emitted by the Global Positioning System (GPS) satellites collected by the Canadian High Arctic Ionospheric Network (CHAIN) GPS receivers are utilized to analyze both amplitude and phase fluctuations. The current ionospheric scintillation paradigm posits that amplitude fluctuations arise from diffraction caused by Fresnel scale ionospheric structures, while refraction is responsible for signal phase variations. The amplitude power spectrum profile consistently displays a rollover frequency, which is not equal to the Fresnel frequency under the Taylor hypothesis. Phase screen theory is used to investigate this phenomenon further and identify an empirical relation between the rollover and Fresnel frequencies. Notably, we have found that the rollover frequency is consistently greater than the Fresnel frequency. Moreover, upon refining the cut-off frequency to mitigate refractive effects on the phase power spectrum, we have found the cut-off frequency consistently exceeds the rollover frequency. Furthermore, the Fresnel frequency extracted from two-component phase spectra tends to be larger than the rollover frequency. Based on our findings, we explore the Fresnel scales are associated with ionospheric irregularities that are producing scintillation.