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Anisotropic density turbulence from the low corona to 1 au

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1 Extended Abstract

Solar radio bursts are strongly affected by radio-wave scattering on density inhomogeneities, changing their observed time characteristics, sizes, and positions. The same turbulence causes angular broadening and scintillation of galactic and extra-galactic compact radio sources observed through the solar atmosphere. Using large-scale simulations of radio-wave transport [1], the characteristics of anisotropic density turbulence from $\sim 0.1R_\odot$ to 1 au are explored. For the first time, a profile of heliospheric density fluctuations is deduced that accounts for the properties of extra-solar radio sources, solar radio bursts, and in-situ density fluctuation measurements in the solar wind at 1 au. The radial profile of the spectrum-weighted mean wavenumber of density fluctuations (a quantity proportional to the scattering rate of radio-waves) is found to have a broad maximum at around $(47)R_\odot$, where the slow solar wind becomes supersonic. The level of density fluctuations at the inner scale (which is consistent with the proton resonance scale) decreases with heliocentric distance as $\langle \delta n_i{}^2 \rangle (r) \simeq 2 \times 10^7\,(r/R_\odot - 1)^{-3.7}$ cm^6 (see Figure 1). Due to scattering, the apparent positions of solar burst sources observed at frequencies between 0.1 and 300 MHz are computed to be essentially cospatial and to have comparable sizes, for both fundamental and harmonic emission. Anisotropic scattering is found to account for the shortest solar radio burst decay times observed, and the required wavenumber anisotropy is $q_\parallel/q_\perp = 0.250.4$, depending on whether fundamental or harmonic emission is involved. The deduced radio-wave scattering rate paves the way to quantify intrinsic solar radio burst characteristics.

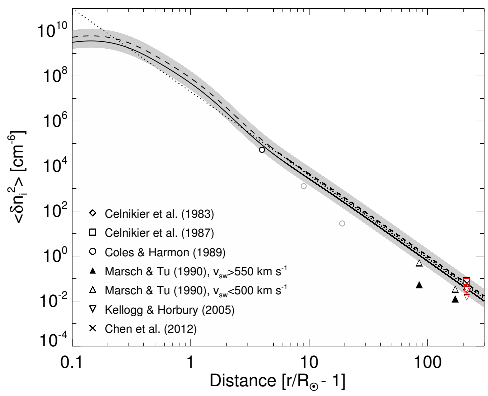

Figure 1. Amplitude of the inner-scale density fluctuations (solid line assuming fundamental and dashed line assuming harmonic).The gray region denotes the range [1/2,2]. The dotted line shows the relation $\langle \delta n_i{}^2 \rangle (r) \simeq 2 \times 10^7\,(r/R_\odot - 1)^{-3.7}$ cm^6.

References

[1] E. P. Kontar, A. G. Emslie, D. L. Clarkson, X. Chen, N. Chrysaphi, F. Azzollini, N. L. S. Jeffrey, M. Gordovskyy, “An Anisotropic Density Turbulence Model from the Sun to 1 au Derived from Radio Observations,” *The Astrophysical Journal*, **956**, Issue 2, October 2023, id.112.: doi: 10.3847/1538-4357/acf6c1