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LOFAR observations of the quiet solar corona

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The solar corona is the hot, tenuous outer atmosphere of the Sun. It is highly structured due to coronal magnetic fields, but generally shows a barometric density profile along magnetic fields, for altitudes well below the sonic critical point that marks the transition towards the supersonic solar wind. If the Sun is observed at a given radio frequency, then the corona becomes opaque below the density level where that frequency corresponds to the local plasma frequency, that is a function of electron density only. LOFAR's frequency range corresponds to the middle (high band) and upper (low band) corona. Since the refractive index of a plasma approaches zero for radio waves near the local plasma frequency, refraction effects are important. A ray path through the solar corona shows total reflectance and cannot connect a source that is located near the solar limb and at such a coronal height, where the wave frequency equals the local plasma frequency, with an observer on Earth. This has important consequences on the appearance of the low-frequency radio Sun under quiet conditions. The diameter of the radio Sun increases with decreasing frequency, as expected from the relationship between electron density and plasma frequency. But it does not appear as a disk with constant brightness temperature, even for an isothermal corona. So deriving the radius of the radio Sun requires fitting of observed intensity profiles to ray-tracing simulations, based on free-free radio wave emission and absorption, as well as refraction. These simulations also depend on the plasma conditions above that radius. LOFAR's capability of simultaneously observing a broad frequency range enables the derivation of a consistent coronal density model. We'll present results for polar coronal density and temperature profiles based on LOFAR low band images.

Summary

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