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LOFAR observations of the quiet solar corona

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1 Introduction

LOFAR is a novel radio interferometer consisting of a central core near Exloo in the Netherlands, remote stations in the Netherlands, and international stations. It observes in two frequency bands, the low band of 10 - 90 MHz, and the high band of 110 - 250 MHz. The Key Science Project "Solar Physics and Space Weather with LOFAR" persues observing the Sun with LOFAR. Solar radio radiation in the low and high band emanates from the upper and middle corona, respectively. The solar corona is not a simple layer with barometric density profile, but highly structured due to coronal magnetic fields. The density of the coronal plasma can be estimated by several means, e.g. coronograph data or radio occultation measurements of spacecraft signals. But they leave a gap in the high corona, at a solar distance of a few solar radii. This region is of special interest, since it is where the transition from a hydrostatic corona to the supersonic solar wind is located.

2 LOFAR quiet Sun images

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. Since the refractive index of the coronal plasma approaches zero there, refraction effects also need to be considered.

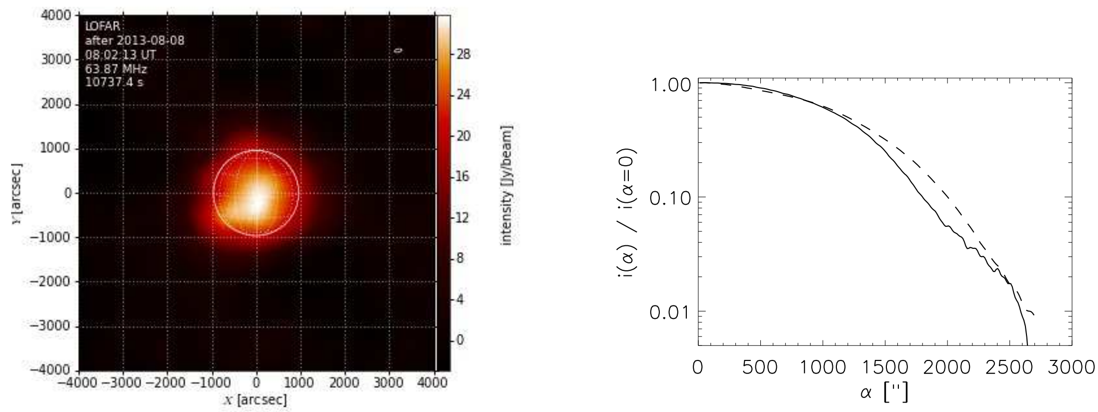

Figure 1. LOFAR solar image of the Sun at 64 MHz from 8 August 2013, 08:02 – 11:02 UT (left), and polar (solid line) and equatorial (dashed line) intensity profiles (right).

Figure 1 shows a LOFAR image of the Sun at 64 MHz. It is obvious that the radio Sun does not appear as a disk with constant brightness temperature, that corresponds to the coronal temperature. Intensity profiles in the polar and equatorial direction show that the Sun appears elongated in the equatorial direction, which is typical for the corona approaching the solar activity minimum. The intensity starts decreasing even for small angular separations, α, of a few 100" from the solar disk center, much less than the 900" photospheric radius of the Sun.

3 Derivation of a coronal density model from LOFAR images

The coronal height where the observed frequency equals the local plasma frequency can be obtained by fitting ray-tracing simulations, which include wave refraction and free-free emission and absorption in the corona, to intensity profiles from the images. Doing so for multiple frequencies yields a coronal density model and temperature profile. We'll present first results for the quiet solar corona.