Diagnosing kappa distribution in the solar corona with the polarized microwave gyroresonance radiation

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There is a growing evidence that the equilibrium electron distribution in the solar corona (especially in the active regions) may be not Maxwellian, but described by the kappa distribution [1]. However, remote detection of the kappa distribution is difficult, because many of its observable effects are subtle and/or indistinguishable from a properly chosen Maxwellian (or combination of Maxwellians). It was recently shown [2] that the gyroresonance microwave emission (which is produced by thermal electrons gyrating in a magnetic field and is typical of the solar active regions) offers a straightforward observational test: while the optically thick gyroresonance emission from a Maxwellian plasma is unpolarized, the emission from the kappa distribution should have a noticeable circular polarization (up to $\sim 10\%$, corresponding to the extraordinary wave). Albeit theoretically evident, practical implementation of this effect is difficult due to a) limited spatial resolution of the radio telescopes, and b) the fact that the distribution of polarization is sensitive also to the magnetic field structure in the corona, which is usually poorly known. In this study, we simulate the gyroresonance emission of a solar active region using an elaborated 3D model [3]; both the Maxwellian and kappa distributions with different indices are considered. We consider different orientations of the active region (following its rotation across the solar disk) and different techniques of the magnetic field reconstruction. The results (i.e., the synthetic intensity and polarization microwave maps) are compared with the spatially resolved microwave observations of the Siberian Solar Radio Telescope (at the frequency of 5.7 GHz); the best-fit model parameters and their confidence limits are determined. We discuss the constraints imposed by the observations on the thermal electron distributions in the solar corona, the sources of ambiguity and the ways to improve the diagnostic capabilities of the radio observations.

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