Theory and diagnostics of the kappa-distribution in the solar atmosphere

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Solar radiation is an important source of information about physical properties of the solar corona and transition region. The presence of the kappa-distribution influences the emissivity of the spectral lines by changing the rates of electron collisional processes such as the ionization, recombination, and collisional excitation. The calculated ionization equilibria for the kappa-distribution showed that the ion abundance peaks are wider and lower in the comparison with the Maxwell distribution and can be shifted in temperature. The shift to lower temperatures in the solar transition region can be very significant. In the solar corona and for temperatures above one million K, maximum abundances can be slightly shifted in the temperatures in the both directions, preferably to higher temperatures for the low kappa values [1]. The electron excitation rates of the high-energy levels of ions are increased and the relative population of these levels are enhanced [2]. The changes in the ionization and excitation equilibrium allow us to propose spectral diagnostics of the kappa-distribution using line intensity ratios involving lines with different excitation energies and/or belonging to different ions [3]. The kappa-distributions also affect the emitted continuum at flare temperatures and hard X-ray energies. The bremsstrahlung is greatly increased, exhibits a strong high-energy tail, and the ionization edges are significantly enhanced [4]. The kappa-distributions modify the responses of EUV and UV filters typically used for the Sun observations, their temperature responses are typically shifted in temperature and widened [2]. The changes of the ionization equilibrium with the kappa-distributions are reflected in the reconstructed differential emission measures, they can move and be either more multi thermal or isothermal [5]. Furthermore, the kappa-distributions of ions can be exhibited in the profiles of the emitted lines measured with high precision. The proposed diagnostics methods for determination of the kappa-distribution were successfully applied to the observed spectra. The values of kappa obtained in the solar transition region, corona and during the flares are typically very low, i.e. the electron distribution in these regions can be strongly non-Maxwellian.

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