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Study of the relationship between the observations of electron distributions in the solar wind and interplanetary magnetic field fluctuations

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The space between the Sun and our planet is not empty. It is filled with the expanding plasma of the solar corona called the Solar Wind, which is a tenuous weakly collisional plasma composed mainly by protons and electrons. Due to the lack of sufficient collisions, the electron velocity distribution function in the Solar Wind usually exhibits a variety of non-thermal characteristics that deviate from the thermodynamic equilibrium. These deviations from equilibrium provide a local source for electromagnetic fluctuations, intimately related to the shape of the distribution function, and associated with the commonly observed kinetic instabilities such as the whistler-cyclotron for $T_{\parallel}/ T_{\perp}>1$, and firehose for $T_{\parallel}/ T_{\perp}<1$ and large enough plasma beta. In this work we carry out systematic statistical study of correlations of various plasma moments and interplanetary magnetic fluctuations as a function of time, in order to describe the role and evolution of these parameters in the solar plasma through the solar cycle. We consider a large time interval during solar cycle 23, ranging from solar minimum (1995-1996) to solar maximum (2000-2001). Using NASA's Wind space mission and its SWE and High-Resolution MFI instruments with resolutions of 6-15 sec and 11 vectors/sec, respectively, we show that collisionless kinetic instabilities can regulate the electron distribution as the whistler-cyclotron and firehose instability thresholds bound the temperature and plasma beta electron distributions, and such regulation is more effective during solar minimum. Subsequently, the magnetic fluctuations level increases as the electron VDF acquires a configuration close to the thresholds. In addition, we note that there is a high difference between the fast and slow wind regimes given a greater tendency towards larger collisionallity and isotropization for low speeds streams, and magnetic fluctuations amplitude decreases as collisional age increases. In summary, our results indicate that collisionless plasma processes and Coulomb collisions effects coexist and both seem to play relevant roles in shaping the observed electron distributions.