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On the Heating of the Solar Corona and the Acceleration of the Solar Wind by Waves

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We investigate possibilities of solar coronal heating by acoustic waves generated not at the photosphere but in the corona, focusing on heating in the mid- to low-latitude corona where the low-speed wind is expected to come from. Acoustic waves of period ~ 100s are triggered by chromospheric reconnection, one model of small scale magnetic reconnection events recently proposed by Sturrock (1999). These waves, having a finite amplitude, eventually form shocks to shape sawtooth waves (N-waves) and directly heat the surrounding corona by dissipation of their wave energy.Outward propagation of the N-waves is treated based on the weak shock theory, so that the heating rate can be evaluated consistently with physical properties of the background coronal plasma without setting a dissipation length in an ad hoc manner. We construct coronal structures from the upper chromosphere to the outside of 1AU for various inputs of the acoustic waves having a range of energy flux of Fw=(1-20) x 10^5 erg cm^{-2} s^{-1} and a period of 60-300s. The heating by the N-wave dissipation works effectively in the inner corona and we find that the waves eceeding Fw = 2x10^5erg cm^{-2}s^{-1} and period over 60s could maintain the peak coronal temperature, Tmax=10^6K. The model could also reproduce the density profile observed in the streamer region. However, due to its short dissipation length, the location of Tmax is closer to the surface than in the observation, and the resulting flow velocity of the solar wind is lower than the observed profile of the low-speed wind. Cooperations with other heating and acceleration sources with larger dissipation lengths are inevitably needed to reproduce the real solar corona.

As a candidate of such heating and acceleration process with larger dissipation length, we discuss the dissipation of linearly polarized Alfven waves and subsequent heating of the corona and acceleration of the solar wind as a cooperating source with the above N-wave process. The linearly polarized Alfven waves steepen their shape non-linearly and eventually form periodic trains of switch-on shocks to heat the surrounding corona. We formulate the dissipation of the switch-on shock trains with respect to variation of the shock amplitude, and we give an estimate of the heating on a fixed coronal structure. Compared to the N-waves with identical period and initial wave energy input, the linearly polarized Alfven waves dissipate much gradually, and the heating dominates that from the N-wave dissipation in the outer corona. This process is expected to work effectively not only as the heating source but as the acceleration source of the solar wind in the outer corona, cooperating with the N-wave dissipation in the inner corona. Although we consider the waves generated at the photosphere by footpoint motions due to the surface convections as well as the waves created in the corona by the small-scale reconnection events, they exhibit quite similar heating profile, since the dissipation in the inner corona is negligible on account of considerably small shock amplitudes there.