Comment on "Heating of the Solar Corona by Dissipative Alfvén Solitons"

In a recent study [1] it is claimed that "myriads of solitons" are continuously created by photospheric convection, and that these further provide an energy source for the two fundamental problems of solar physics, viz., the heating of the solar corona and the acceleration of the solar wind. Both the coronal heating and the wind acceleration are fundamental problems of solar physics and, hence, such claims should be taken with caution. It is true that the photosphere is covered by convective gas motions with typical velocities of about 0.5 km/s. The kinetic energy per unit volume stored in this macroscopic motion of a mainly neutral gas exceeds, by several order of magnitude, the energy required to heat the corona. Clearly, only a tiny fraction of this convective kinetic energy of the neutral gas would be sufficient to heat the higher layers to the observed temperatures. Therefore, it appears natural to investigate if such a huge reservoir of macroscopic motions of neutral gas could generate waves in the lower solar atmosphere which would propagate towards the higher atmospheric layers and dissipate their energy there. Such a scenario is attractive in view of the fact that this macroscopic motion in the lower atmosphere is permanent and widespread throughout the solar surface. However, the model used in Ref. [1] assumes (i) a collisionless photosphere and (ii) the consequent excitation of Alfvén waves by the photospheric convection. Both these assumptions may be far from reality. In fact, in the photosphere collisions are so frequent that neither ions nor electrons are magnetized. This implies that modes which involve the gyromotion of plasma species cannot possibly develop, and, consequently, this scenario cannot be used in solving the problem of the coronal heating and the solar wind acceleration.

In Table I, the collision frequencies and the magnetization of ions (protons) and electrons in hydrogen gas are given. The parameters for the quiet Sun are taken from Ref. [2]. Note that similar parameters may be found elsewhere, see Ref. [3] and references cited therein. The cross sections σ_{jn} for electron-neutral and ion-neutral collisions are from Refs. [4–6]. Here, we use $\nu_{jn} = n_{n0}\sigma_{jn}v_{Tj}$. The collision frequency of electrons with charged species is given by the Spitzer-Härm formula $\nu_{ec} \equiv \nu_{ee} + \nu_{ei} \simeq 2\nu_{ei} = \{4n_{e0}(2\pi/m_e)^{1/2}[ee_i/(4\pi\varepsilon_0)]^2 L_{ei}/[3(\kappa T_e)^{3/2}]\}$, where the Coulomb logarithm is given by $L_{ei} = \log[12\pi\varepsilon_0(\varepsilon_0/n_{i0})^{1/2}(\kappa T_e)^{3/2}/(ee_i^2)]$. For ions we have $\nu_{ii} = \{4n_{i0}(\pi/m_i)^{1/2}[e_i^2/(4\pi\varepsilon_0)]^2 L_{ii}/[3(\kappa T_i)^{3/2}]\}$. In calculating the magnetization of the plasma species one must include the total collision frequencies. We note that at $h =$ 0 km for $B_0 = 10^{-3}$ T, $\Omega_i/\nu_{it} = 6\times10^{-5}$, $\Omega_e/\nu_{et} = 1.3\times10^{-2}$. For metal ions [7] with $m_i = 35m_p$ the calculation is not straightforward because σ_{in} is not known. As a first guess, we take the value for protons multiplied by 35. Then, $\nu_{in} = n_{n0}\sigma_{in}[m_n/(m_i+m_n)][8\kappa T_i/(\pi\mu)]^{1/2}$, where n denotes the neutrals (hydrogen), and $\mu = m_im_n/(m_i+m_n)$ is the reduced mass. For example, at $h =$ 250 km for metal ions this yields $\Omega_i/\nu_{it} = 6.6\times10^{-6}$. Consequently, neither ions nor electrons are magnetized, regardless of the type of ions. For ions this remains so for any realistic value of the magnetic field. We conclude that the ions in the photosphere are not magnetized and, therefore, the Alfvén waves, which in Ref. [1] are assumed to be massively produced by the convective motion, are not a likely source for the coronal heating and the solar wind generation.

TABLE I. The collision frequencies (in Hz) and magnetization ratio of electrons and protons (in m/s) in the photosphere for the magnetic field $B_0 = 10^{-3}$ T and for several altitudes h (in km). Here $\nu_{it} = \nu_{in} + \nu_{ii}$, $\nu_{et} = \nu_{en} + \nu_{ei} + \nu_{ee}$.

h	ν_{in}	ν_{ii}	ν_{en}	ν_{ei}	Ω_i/ν_{it}	Ω_e/ν_{et}
0	1.6×10^9	5×10^7	10^{10}	1.5×10^9	6×10^{-5}	1.3×10^{-2}
250	2.6×10^8	3.8×10^6	2.2×10^9	1.2×10^8	3.6×10^{-4}	7.3×10^{-2}
515	2.4×10^7	4.9×10^5	2.1×10^8	1.5×10^7	4×10^{-3}	0.73

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