Geophysical Research Abstracts
Vol. 12, EGU2010-15622, 2010
EGU General Assembly 2010
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Formation and primary heating of the solar coronal structures

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It is shown that the two-fluid formalism in which the bulk velocity field is treated at par with the magnetic field, has the potential of serving as an excellent model for investigating the observed coronal structures and dynamical phenomena in solar atmosphere. It is suggested that the interaction of the fluid and the magnetic aspects of a plasma may be a crucial element in creating the enormous diversity in the solar atmosphere - the structures which comprise the solar corona can be created by particle (plasma) flows observed near the Sun's surface—the primary heating of these structures is caused by the viscous dissipation of the flow kinetic energy. Explicit models (theory as well as simulation) for the formation and heating of coronal structures are worked out. Investigations show that for efficient loop formation, the primary up-flows of plasma in the chromospheres / transition region should be relatively cold and fast (as opposed to hot). It is during trapping and accumulation in closed field regions, that the flows thermalize (due to the dissipation of the short scale flow energy) leading to a bright and hot coronal structure. The formation and primary heating of a closed coronal structure (loop at the end) are simultaneous. The coronal loop, in fact, is created just when up-flows (whatever their initial temperature) enter the closed magnetic field region; heating will always take place due to the dissipation of short–scale flow energy. The heating caused by the dissipation of flow energy may, in addition, be augmented by one or several modes of secondary heating. In our model, the "secondary heating" may occur to simply sustain (against, say, radiation losses) the hot bright loop. The emerging scenario, then, is not the filling of some hypothetical virtual loop with hot gas. The loop, in fact, is created by the interaction of the flow and the ambient field; its formation and heating are simultaneous and "loop" has no ontological priority to the flow.

Numerical simulations were performed to explore the dynamics of the formation of hot closed coronal structure in the Solar Atmosphere. Two-fluid magneto-hydrodynamic model of Mahajan et al. (2001), where it is assumed that plasma is fully ionized, was used. The interaction of primary plasma flows (emerging from the solar surface) with the ambient atmospheric primary closed magnetic fields is considered for a variety of boundary conditions; in the two-fluid equations the viscous dissipation is taken to be local in time and space. Significant results are:

1. Primary plasma flows are capable of thermalizing during interaction with primary magnetic fields (that are curved) to form the hot coronal structure.

2. Two distinct eras are distinguishable in the life of a hot closed structure – a fast era of the formation (plus primary heating), and a relatively calm era of in which the hot structure persists in a state of quasi-equilibrium.

3. Parameters of the hot closed structure (in quasi-equilibrium) are fully determined by the characteristics of the primary flow and the ambient magnetic fields; the greater the primary flow initial velocity and initial magnetic field $\boldsymbol{B}_0$, the hotter is the coronal base. For the same primary flows the maximum heating is achieved at some height independent of $\boldsymbol{B}_0$ (the agreement of this simulation prediction with observations is extremely important). As expected, the greater the resistivity, the shorter is the life-time of the quasi-equilibrium structure

4. The formation time of the hot closed structure is strictly dependent on the magnitudes of primary flow and primary magnetic field, as well as their initial time dependence (life-time).

5. The duration of the primary heating is directly determined by the parameters of primary flow and magnetic

fields. Greater the fields, the faster is the primary heating.

S.M. Mahajan, R.Miklaszevski, K.I. Nikol'skaya & **N.L. Shatashvili.** ***Formation and Primary Heating of the Solar Corona - Theory and Simulation*****. Phys. Plasmas**. **8**, 1340 (2001).