Key processes in the bow shock region

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When the CME velocity relative to the velocity of the unperturbed solar wind exceeds the local magnetosonic speed, which is approximately equal to the Alfven speed in the solar corona, a piston shock forms in the leading portion of the perturbed zone. In this case, the CME is the piston. Identifying blast-wave shocks, which can also arise during CME formation, is a much more complex problem. The difference from piston shocks is that a blast-wave shock originates from the explosions that frequently accompany CME formation, and further propagates freely without any CME piston effects. For example, Earth's bow shock (BS) is a piston shock. The front of the Bow Shock (BS) is the region where the parameters of the Solar Wind (SW) undergo strong changes, especially in the "nose" part. The particle number density and the intensity of the tangential component of the magnetic field increase approximately by a factor of 4 behind the front, the normal velocity component decreases by the same factor (according to data of well-known satellite missions – GEOTAIL, CLUSTER-II, THEMIS; interplanetary shocks - in SPECTR-R). If almost all SW energy before the front is concentrated in the progressive motion, then behind the front it is concentrated in the energy of compressed gas and magnetic field. The bow shock front is the main converter of solar wind kinetic energy into electromagnetic energy (Ponomarev et al. 2006, a). When passing through the bow shock front, the intensity of the tangential component of the SW magnetic field and the plasma density increase several fold. Therefore, among other things, the BS front is a current sheet. It is possible to show that current is diverging in this layer, that is the front is the generator of the current. Since plasma with magnetic field passes through the front, electric field arises in the front reference system. Thus, the BS front is a source of electric power. There is a potential difference between the BS front and the magnetosphere, unequivocally (since the Transition Layer (TL) magnetic field is determined by the SW magnetic field) associated with the velocity of the transition layer plasma flow. Thus, the magnetopause potential is functionally related to SW parameters. The power consumed by the magnetosphere is spent on the compressor work and consists of active and reactive power. The active part covers losses in the ionosphere (ohmic, primarily), the reactive part returns to the magnetospheric compressor (Sedykh, Ponomarev 2002; Sedykh 2014; Sedykh and Ponomarev 2012). We shall assume the bow shock front to be a paraboloid of rotation with its axis coinciding with the X axis in the solar-magnetospheric coordinate system. In the paper we shall be limited to a simple case - we shall consider the dependence only from coordinate X. Certainly, more full decision of the general problem (when dependence not only on one coordinate is examined) has to be considered. However, it is not possible to solve at once a complex problem analytically. Therefore in this study we shall be limited to such statement of a problem. Further, the obtained solution can be generalized on more difficult cases. It is clear that the primary energy source for magnetospheric processes is the solar wind, but the process of energy transfer from the solar wind into the magnetosphere, or rather, to convecting magnetospheric plasma, appears to be rather complicated. The solar wind energy also feeds the ion acceleration process, the generation of waves in the region of bow shock, and the energy necessary to build up the foreshock.