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Solar Flare Model – 3D MHD Simulation and Comparison with Observation

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The flare electrodynamical model is developed on the base of 3D MHD simulations that demonstrates current sheet creation in corona above an active region. The current sheet creation takes place due to MHD disturbances arriving from the photosphere and focusing around a magnetic singular line, or due to new magnetic flux emergence near a pre-existing flux, if the polarity of the new magnetic flux is opposite to that of the old flux. In the simplest case the singular line is a zero X-type magnetic line. It is shown that the energy order of 10^{32} erg is accumulated in the current sheet magnetic field during 2-3 days before the flare. The current sheet appears above an active region. Numerical simulations are carried out for several flares. The initial and boundary condition are set from the preflare photospheric measurements. The model explains flare and coronal mass ejection production. The current sheet stability before a flare is supplied by plasma flow along the sheet and existence the normal magnetic field component. The current sheet becomes unstable after quasistationary evolution and decays due to fast magnetic reconnection. If a vertical current sheet decays, the plasma ejected in the interplanetary space by magnetic tension producing a coronal mass ejection. In that case the solar flare and CME appear in the same explosive event. Plasma accelerated downward produces post flare loops. The plasma heating during fast reconnection produces X-ray emission in corona. This thermal X-ray emission above the active region at a flare development has been demonstrated by Yohkoh and RHESSI missions. It is shown that high frequency continuum of radio emission appears from the current sheet. Spectra solar of relativistic protons obtained from neutron monitors correspond to particle acceleration in the Lorenz electric field directed along a singular line. The important feature of a current sheet is the normal magnetic component. Its existence leads to Hall electric field appearance and field-aligned currents gener-

ation. The electrons accelerated in upward field-aligned currents produce sources of hard X-ray emission in the leg foundations of a postflare loop. Legs of a loop move apart during fast reconnection. This phenomena usually observed in visible radiation as ribbons. The mechanism of ribbons and X-ray emission reminds aurora production where precipitating electrons gain their energy in potential drops (double electric layers or regions of anomalous resistivity) along upward field-aligned currents. The possibility of Hall electric field generation in a current sheet has been for the first time demonstrated in measurements of electric and magnetic fields on the IKB-1300 space craft. The similarities of flares and substorms are discussed.