FLARIX model of Si IV and O IV emission at the loop footpoints due to an electron beam transport through the transition region

Elena Dzifcakova[1], Jana Kasparova[1], Jaroslav Dudik[1], Alena Zemanova[1]

[1]Astronomical Institute of the Czech Academy of Sciences, Ondrejov, Czech Republic

Solar flares are characterized by persistent particle acceleration. The accelerated particles transport energy from the coronal magnetic reconnection site to the lower atmosphere, where most of the flare emission originates.

We modelled the Si IV and O IV emission originating at loop footpoints heated by an electron beam. To do that, we used the radiation-hydrodynamical simulations via FLARIX code which allows to calculate time dependent plasma parameters along the loop. Radiative transfer was treated in detail for atoms and ions important for radiative losses. Energy was deposited via short-duration electron beams with a triangular profile in time, peaking at 1, 3, or 5s, and with energy flux ranging from 1 to 9 x 1010 erg cm-2s-1. The short heating duration corresponds to fast energy release via the process of slipping reconnection of flare loops moving through a given location in the flare ribbon during a short time only.

Subsequently, we calculated the non-equilibrium ionization states of silicon and oxygen, taking into account the non-Maxwellian electron distribution of the electron beam component. The evolution of Si IV and O IV line intensities was modelled including the effects of non-equilibrium ionization, power-law beam contribution in both ionization and excitation; as well as suppression of dielectronic recombination at the high densities within the flaring loop. The non-equilibrium abundances of both ions were found to differ from the equilibrium ones by more than one order of magnitude. The effect of density suppression of dielectronic recombination is very important, as the ion abundances calculated without it can be several times lower than when this effect is included.

We found that the maximum emissivity of Si IV and O IV ions occurs in a hot 'bubble' formed in the upper chromosphere at the location of the maximum of beam energy deposition. Overall, the main contribution to the total intensity of ions lines along the flare loop comes from the hot bubble in optically thin cases or from plasma above this 'bubble' when the plasma is optically thick. Ratios of the calculated Si line intensities to O IV intensities are sensitive to the parameters of the electron beam. O IV abundances and line intensities follow any changes in plasma parameters more slowly than Si IV ones. The synthetic IRIS Si IV lines are also found to be optically thick for many electron beam parameters.

Our results show that all considered processes are important and cannot be neglected in the theoretical calculations of the synthetic line intensities in the flaring atmosphere.