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Role of suprathermal runaway electrons returning to the acceleration region in solar flares

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During solar flares, a large flux of energetic electrons propagate from the tops of reconnecting magnetic flux tubes toward the lower atmosphere. Over the course of the electrons' transport, a co-spatial counter-streaming return current is induced, thereby balancing the current density. In response to the return current electric field, a fraction of the ambient electrons will be accelerated into the runaway regime. We develop a model in which an accelerated electron beam drives a steady-state, sub-Dreicer co-spatial return-current electric field, which locally balances the direct beam current and freely accelerates a fraction of background (return-current) electrons. The model is self-consistent, i.e., the electric field induced by the co-evolution of the direct beam and the runaway current is considered. We derive the range of injected beam fluxes for which the collisional (Ohmic) treatment of the return current is no longer acceptable. We find that (1) the return current electric field can return a significant number of suprathermal electrons to the acceleration region, where they can be further accelerated to higher energies, runaway electrons can be a few tens of percent of the return current flux returning to the nonthermal beam's acceleration region, (2) the energy gain of the suprathermal electrons can be up to 10-35 keV, (3) the heating rate in the corona can be reduced by a factor three for medium range injected fluxes in comparison to models which neglect the runaway component. The results depend on the injected beam flux density, the temperature and density of the background plasma.

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