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Suprathermal Electron Transport and Electron Beam Formation in the Solar Corona

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Solar type III radio bursts associated with solar flares are believed to be produced by electron beams propagating in the solar corona via an electron two-stream instability (ETSI) [1]. Coronal type III radio bursts are produced by electron beams within the solar corona. These electron beams are found ≥ 300 Mm above the acceleration region [2] and have velocities ranging from 0.1c to 0.6c, where c is the speed of light. However, the mechanism for producing these electron beams remains unclear.

We use kinetic transport theory [3] to investigate the competition of three effects in mediating the transport of suprathermal electrons and the formation of coronal electron beams within the solar corona. We show that magnetic focusing can suppress Coulomb collisions and turbulent scattering, leading to the formation of coronal electron beams. As a result, coronal electron beams develop and form efficiently from suprathermal electrons over the requisite observational distance (i.e., ≥ 300 Mm above the photosphere). Their bulk velocity can reach a saturated speed larger than the ETSI threshold and produce coronal type III radio bursts. Over this observation-constrained distance, the specific spatial configuration of the magnetic field of flares has little effect on the formation of coronal electron beams.

Moreover, using a group of observed velocity and location distributions of coronal electron beams, our model predicts that the temperature of the flare acceleration regions ranges from 5×10^6 to 2×10^7 K. The coronal electron beam velocities range from 0.1c to ~0.6c for locations from 400 to 700 Mm above the acceleration region, which is well consistent with the observations. Our model also suggests that the acceleration region may have a boundary where the temperature decreases. As a result, the bulk velocity of coronal electron beams can abruptly reach more than triple (even up to 10 times) the coronal background thermal velocity and produce coronal type III radio bursts; this explains the origin of electron beams with velocities up to 10 times the thermal velocity.

References

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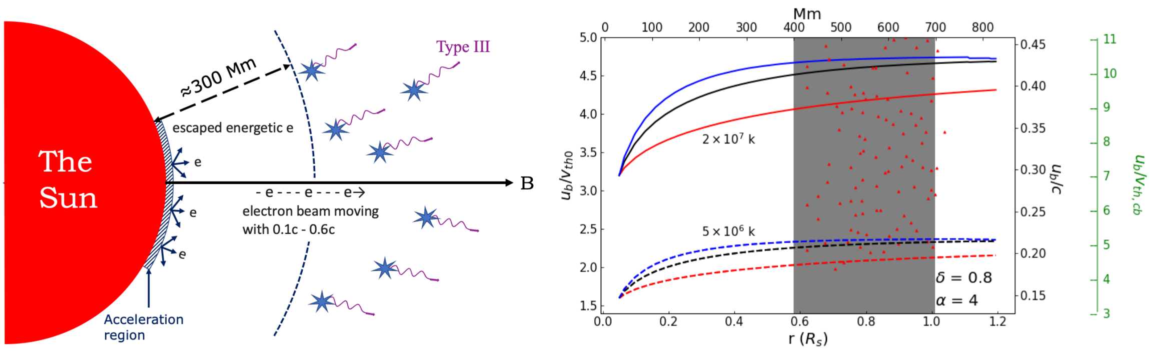

Figure 1. Left. Schematic illustration of suprathermal electron transport and coronal electron beam formation inside the solar corona along a radial magnetic field. **Right.** Radial evolution of the bulk velocity of suprathermal electrons with 10^6 and 10^7 K. Red dots represent the observed electron beam velocities for coronal type III bursts. Comparison between numerical results and observations suggests that the temperature in the acceleration region ranges from 5×10^6 to 2×10^7 K, consistent with observations.