Geophysical Research Abstracts
Vol. 15, EGU2013-1209-4, 2013
EGU General Assembly 2013

TGF electron avalanches and gamma-ray emission - a new detailed simulation software package

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In designing the MXGS coded mask imager of the ASIM mission to detect and locate gamma-rays from Terrestrial Gamma-ray Flashes it has been necessary to simulate the expansion of gamma-ray photons from 15-20 km altitudes to make some estimate of TGF spectra and the diffuse extent of a TGF beam observed at orbital altitudes. From this a new detailed simulation software package has been developed to take into account not just electron scattering via Bremsstrahlung and ionization, but also a range of spatial electric field distributions which can drive the runaway electron avalanche process, and the evolution of electron and ion spatial density which might choke avalanche growth or stimulate a quasi-simultaneous lightning discharge.

The software package uses the standard physics of keV-MeV photon interactions, Bremsstrahlung scattering and photon emission, with Elwert modifications, including the Sommerfeld-Maue electron wave function variation and electron shielding effects. It also includes the physics of close range Moller electron ionization scattering, distant electron Coulomb ionization, Binary-Electron-Bethe models of electron scattering, and positron Bhabha scattering and annihilation. It also uses a superparticle spatial mesh system to control particle-momentum densities, electric field evolution, and any exponential avalanche growth.

Results will be presented of simulations using macro electric fields expected in storm clouds and the micro fields expected around streamer tips, and will include videos showing the detailed time evolution of electron and photon flux fields, local ion densities and, particularly, induced local electric fields and their effect in inhibiting or stopping a TGF particle avalanche.

The software is script driven and intended for users who wish to concentrate on the effect of local electric fields on TGF origin and avoid the additional GEANT4 type overheads and complexities of all the scattering processes involved. It will also provide specific subroutines which will take care of all particle tracking, scattering and scattering products, for users who wish to develop their own Monte Carlo simulation methods.