3rd URSI AT-AP-RASC, Gran Canaria, 29 May – 3 June 2022

Controlling Effect of the Cold Plasma Density on Acceleration and Loss of Electrons at Ultra-Relativistic Energies

Yuri Shprits*(1), Hayley Allison(2), Alexander Drozdov(3), Dedong Wang(4) Nikita Aseev(5), Irina Zhelavskaya(6), Maria Usanova(7)

(1) Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, Telegrafenberg, 14473 Potsdam, Germany, e-mail: yshprits@gfz-potsdam.de
(2) Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, Telegrafenberg, 14473 Potsdam, Germany, e-mail: haylis@gfz-potsdam.de
(3) University of California Los Angeles, Los Angeles, CA 90095, United States, email: adrozdov@ucla.edu
(4) Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, Telegrafenberg, 14473 Potsdam, Germany, e-mail: dedong@gfz-potsdam.de
(5) Moscow Institute of Physics and Technology Address: 141700, Russia, email: nikita.aseev@phystech.edu
(6) Helmholtz-Zentrum Potsdam, Deutsches GeoForschungsZentrum GFZ, Telegrafenberg, 14473 Potsdam, Germany, e-mail: irina@gfz-potsdam.de
(7) University of Colorado at Boulder, Boulder, United States, email: maria.usanova@colorado.edu

Measurements from the Van Allen Probes mission clearly demonstrated that the radiation belts cannot be considered as a bulk population above approximately electron rest mass. Ultra-relativistic electrons (~>4Mev) form a new population that shows a very different morphology (e.g. very narrow remnant belts) and slow but sporadic acceleration. We show that acceleration to multi-MeV energies can not only result of two-step processes consisting of local heating and radial diffusion but occurs locally due to energy diffusion by whistler-mode waves. Local heating appears to be able to transport electrons in energy space from 100s of keV all the way to ultra-relativistic energies (>7MeV) and is a dominant process for acceleration to ultra-relativistic energies. Acceleration to such high energies occurs only for the conditions when cold plasma in the trough region is extremely depleted down to the values typical for the plasma sheet. There is also a clear difference between the loss mechanisms at MeV and multi MeV energies The difference between the loss mechanisms at MeV and multi-MeV energies is due to EMIC waves, that can very efficiently scatter ultra-relativistic electrons, but leave MeV electrons unaffected. These observations and modelling clearly show that cold plasma at eV energies has a controlling effect on the trapped electrons at energies seven orders of magnitude more energetic. Depletion in cold plasma is a requirement for acceleration while fast loss occurs only in the regions of high plasma density. We also present how the new understanding gained from the Van Allen Probes mission can be used to produce the most accurate data assimilative forecast. Under the recently funded EU Horizon 2020 Project Prediction of Adverse effects of Geomagnetic storms and Energetic Radiation (PAGER) we will study how ensemble forecasting from the Sun can produce long-term probabilistic forecasts of the radiation environment in the inner magnetosphere.