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Effect of the concomitancy of (i) Betatron deceleration & acceleration, of (ii) up-lift & down-lift of mirror points altitudes, and of (iii) pitch angle scattering of relativistic electrons

Joseph Lemaire (1) and Viviane Pierrard ()

(1) BISA - Brussels (joseph.lemaire@aeronomie.be), (2) BISA - Brussels (viviane.pierrard@aeronomie.be)

Main-phases of geomagnetic storms are generally observed following the southward turning of the IMF. The northward component (B_z) of the equatorial magnetic field intensity diminishes in the inner magnetosphere during the main phase. As a consequence of the conservation of the first adiabatic invariant (μ = W_{-}/B) the perpendicular kinetic energy of the charged particles is then reduced by: Δ W_m = W_m Δ B_m / B_m as a result of Betatron deceleration. Furthermore, numerical simulations by Lemaire *et al.* (2005; *doi: 10.1016/S0273-1177(03)00099-1*) verified that h_m, the altitude of mirror points, increases according to: Δ h_m = -? (R_E + h_m) Δg_m / B_m. Thus a particle mirroring at an altitude of 1000 km, before a storm will be lifted up to 1100 km along magnetic field line for Dst = - 50 nT: Δ h_m = 100 km, or more when Dst = - 50 nT.

A key consequence of this overall upward shift of the mirror point altitudes is that more RB electrons accumulate higher up above the denser layers of the atmosphere. This tends to reduce their collisions frequency with atmospheric constituents, and to increase considerably the trapping life-times of all particles whose pitch-angle is next to the loss cone angle. This reduction of the collision frequency will last several hours, beyond the duration of the main phase: less atmospheric losses during the main phase of geomagnetic storms and beyond!

Furthermore, *non-resonant wave-particle (w-p) interactions* of ambient RB electrons with VLF waves and/or ULF waves produce pitch-angle scattering: half of the time pitch-angles are randomly increased, and half of the time they are decreased. In the first case, when the pitch angle becomes closer to 90° the trapping life-time becomes larger and these particles pile up closer to the equatorial plane. Non-resonant w-p interactions contribute therefore to prolong residence times of half of the trapped particles, even beyond that resulting from to the uplift of the mirror points as described above.

During final recovery phases, the trapped electrons are now adiabatically accelerated by the reverse betatron mechanism, and their mirror points move back to lower altitudes. The fluxes of RB particles are then recovered adiabatically to their pre-storm values when w-p interactions are ignored as well as additional injection or losses.

However when the effects of VLF / ULF w-p interactions are predominant during the whole storm time the post-storm fluxes should be smaller than the pre-storm fluxes. When w-p interactions are effective only during the main-phase but not during the recovery phase the post-storm fluxes of RB electrons should exceed the pre-storm one. Other situations will be discussed during the presentation.

Lemaire J.F., S.G. Batteux and I.N. Slypen, *J. Atmos. SolarTerr. Physics,* **67**, 719-727, 2005. (*doi: 10.1016/S0273-1177(03)00099-1)*