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CONTRIBUTED POSTER

Analysis and interpretation of ion injections into the ring current during magnetospheric substorms

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Abstract: We investigate the origin and transport of ring current particles during magnetospheric substorms, their interaction with the tail current and the correlation of their dynamics with the substorm phases. A test-particle solver, developed for such purposes, is coupled to models providing the Sun-driven geomagnetic field and the electric fields due to convection, corotation and magnetic induction. In order to trace the plasma ion sources of the substorm-time injections, test-particle simulations are conducted in reverse-time, using data from RBSP measurements as final conditions and following the ion motions up to the initial state.

1 Research objectives

Our work is in the field of analysis and interpretation of the dynamics of the ring and near-Earth tail currents during geomagnetic storms and magnetospheric substorms [1], focusing on the tracking of the origin of energetic ions observed inside the ring current region in the course of such disturbances. Here, we present results from the simulation of the kinetics of charged particles in the inner magnetosphere, when isolated substorms are occurring. We conduct test-particle simulations in the reverse-time direction (backtracing), using spacecraft data as a starting point and following the ion orbits up to the event setoff, in order to determine the plasma particle sources of the substorm-time injections. For a description of the model for the geomagnetic field, the electric field and the particle motion solver, which we have employed for the derivation of the numerical results, the reader is referred to [2] (the specific work has been also presented in this conference as a contributed lecture).

2 Results and discussion

In the course of magnetospheric disturbances, energetic ions are usually injected into the ring current during the event phases. This effect is driven by the combination of the storm-time convection and induction electric fields, and normally has a peak during the substorm relaxation phase due to the large electric field gradients at that time. The study of the dynamics of oxygen and hydrogen ions as a function of the particle initial conditions has shown that both species are injective, but O^+ tend to be more energetic inside the ring current [2]. In this work, we address the case study of an isolated substorm event, detected on 7/4/2014 between 14.00 and 18.00 GMT. During the 4 hours of the event, the variations of the associated geomagnetic indices were $\Delta(AL) = -700$ nT, $\Delta(AU) = 250$ nT, $Kp = 3 \to 4 \to 2$ and $Dst = 15 \to 5 \to 2$ nT, as given in Figures 1a, 1b. We have adopted the ion count rates measured from RBSP, as well as its orbital positions, in order to assign consistently the initial conditions for the test particle coordinates and energies (see Figure 1c). The test ions were detected in the region near $5R_E$ at the time of the event completion ($t = 18$ h). From this starting point, we have traced the particle motions backwards in time in order to track the origin of the observed energetic ions, and the results are shown in Figure 2. The main picture is that there are O^+ ion injections from a wide region, ranging from 10 to 30 R_E (see Figure 2a), and starting nearly 2 hours before the event initiation. On the contrary, as seen in Figure 2b, the majority of hydrogen ions reside in the outer ring current; this

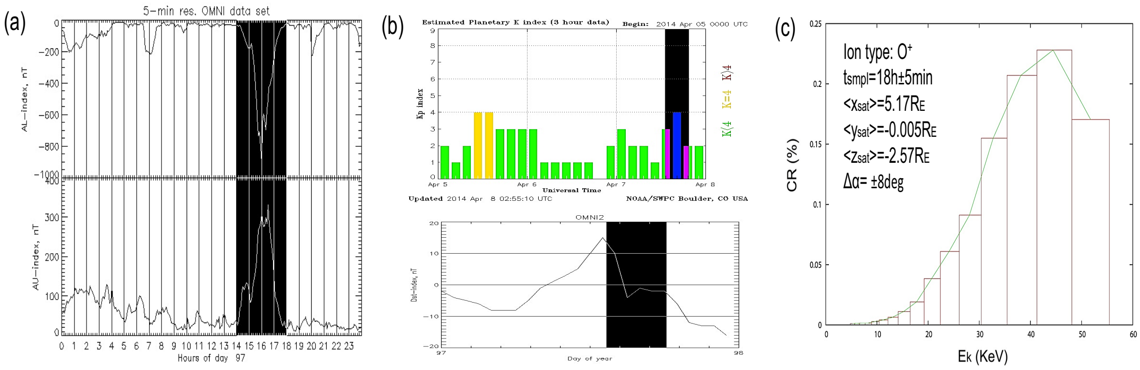

Figure 1: Overview of the isolated substorm event detected on 7/4/2014 between 14.00 and 18.00 GMT: (a) Daily variation of the geomagnetic indices AU and AL, (b) 3-day variation of Kp and daily variation of Dst in the period close to the event, (c) Distribution of the O^+ ion count rates at the event temination (18.00 GMT), measured from RBSP-A, over the ion energies.

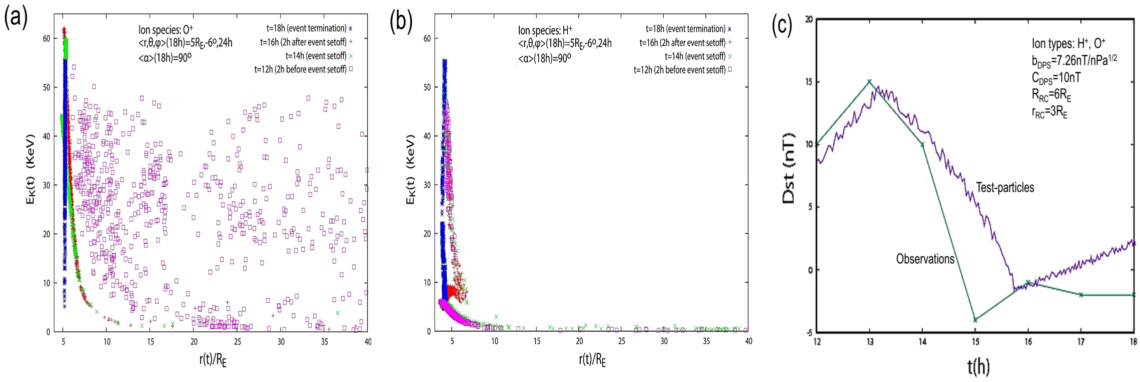

Figure 2: (a), (b) Distribution of the backtraced O^+ and H^+ over the radial distance and energy, and its evolution from the event stop time (18.00 GMT) back to -2 h (event peak), -4 h (event start) and -6 h, (c) Numerical computation of the Dst index as compared to the observed values.

aspect was traced back to 10.00 GMT, i.e. 4 hours before the event setoff. Our initial observation is the absence of a direct correlation of the different substorm characteristics: The occurrence of the injection seems to be out-of-phase with the values of the field stretching indexes AL and AU, and energetic oxygen and hydrogen ions exist in the outer ring current region well before the event initiation. This behaviour may be in connection to the variation of Kp from 1 to 3 and of the dynamic pressure from 2 to 4 nPa, which took place starting from 3 hours before the substorm. Regarding the distribution of the counted oxygen ions over the radial distance, the source of O^+ injections is found to have a peak around 10 R_E, whereas the kinetic energy of the ions is reduced as a function of the radial distance. There is also a large population of low-energy ions in the plasma sheet, which are an active part of the injection (this is in accordance to our previous study [2]). Finally, in Figure 2c, we show the result of the numerical computation of the Dst index from the Dessler-Parker-Sckopke (DPS) relation, which connects the energy stored in the plasma populations with the associated magnetic perturbations, also in comparison to the observed values. In this computation, the ring current is assumed as a torus with radii $R_{RC} = 6R_E$ and $r_{RC} = 3R_E$, which contains the H^+ and O^+ ion species, and the values of the plasma density and dynamic pressure are given by observations.

References

[1] Daglis, I.A., et al: 1999, Rev. Geophys. 37, 407.

[2] Tsironis, C., et al: 2015, Proc. 12^{th} Hel.A.S. Conference, contr. S1-2.