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COMPARATIVE STUDY OF THE AURORAL BREAKUP AND PSEUDOBREAKUP BY CRRES PARTICLE MEASUREMENTS

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Abstract. Pseudobreakup and normal developed substorm were registered within one hour interval on January 24, 1991 by ground-based magnetometers and particle detectors on board CRRES satellite. IMF Bz component before pseudobreakup remains southward long enough to distinguish pseudobreakup from the weak substorm. Comparison of the observations allows to advance into understanding how a pseudobreakup and a substorm onset differs. We found that field aligned electron flux was smaller and effective energy lower than during the substorm activations. Also the proton enhancement during pseudobreakup was smaller by intensity and restricted only by soft energy as compared with regular substorm breakup.

Introduction

Pseudobreakups (PB) were introduced by Akasofu [1964] as a weak substorms which started not on the equatorial, but on more high-latitude auroral arcs. Davis and Hallinan [1976] defined PB as a weak localized substorms. Several main substorm onset features were found in the PBs: intensification of the auroral electrojet and auroral electron enhancement [Koskinnen et al. ,1993], Pi2 pulsations [McPherron, 1991], magnetic field dipolization [Nakamura et all., 1994]. All authors concluded that the only one difference is an absence of the expansion phase, fast decline of the activity after the PB.

Opposite opinion which we can accept and support, was presented by Kamide [1998], namely that PB is not a weak substorm but different specific event. Weak substorms, he said, are weak because energy accumulated in the magnetosphere during growth phase was not large. Weaker substorm tend to occur to higher latitudes, along the contracted auroral oval. As for PB, energy accumulation (or deviation of the magnetosphere configuration from the stable one) is sufficient for a substorm development, but some unknown mechanism depresses future development of the expansion.

It is important to note, that PB should not be compared with substorm onset which consists on chain of several activation, but with a first auroral activation of the breakup (AB). The main question of the problem might be expressed as following: why PB activation does not prepare conditions for the next activation?

As an activations have typical duration of 2-4 minutes, one need temporal resolution of several seconds. Investigations of the activation fine structure using CRRES particle measurements [Lazutin et al.,2007] allow to found new features of the transition from growth to active substorm phases.

Observations

For the comparison of the PB with AB we will use ground-based observations and particle measurements on board of the CRRES satellite on January 24, 1991 at 16:00-16:20 UT and 16:54-17:10 UT accordingly. CRRES LEPA detectors measured low-energy electrons and ions from 50-100 eV to 20 keV [Hardy et al., 1993]. EPAS device measured energetic particles from first tens to hundreds keV [Korth et. all, 1992]. CRRES position during the time interval under consideration was near the equatorial plane at the magnetic longitude of Dixon observatory. The main substorm with breakup at 16:54 UT was analyzed earlier [Maynard et al., 1996, Kozelova et al., 2002], but only with high-energy particle data.

From several auroral magnetic stations only Dixon measured magnetic bay in H-component during PB, while AB was accompanied by much stronger bay in wide latitude range (Figure 1). Besides, according to IMP-8 measurements the Bz-component of the IMF was negative from 14:10 UT until 16:40UT. Therefore PB was presided by long growth phase and it was located at the typical substorm onset latitude. One may suppose that both PB and AB in this day have approximately even amount of energy stored in the magnetoshere.

Particle data of LANL geostationary satellites which can be found in the Internet (not shown) confirm that growth phase was well developed, because two night side satellites registered deep dropouts before PB. Typical for the substorm onsets fast dropout recovery and energetic particle injection were registered only in a narrow area around the Dixon during PB and in wide latitudinal range during AB. Thus, we have strong evidences that at 16 UT we observed not a weak substorm but PB defined in a Kamide [1998] sense, which occurs at the substorm latitude of subsequent AB, but in a longitudinal confined region. However, injection of the energetic electrons and the degree of the dipolarization during PB are such large as during AB.

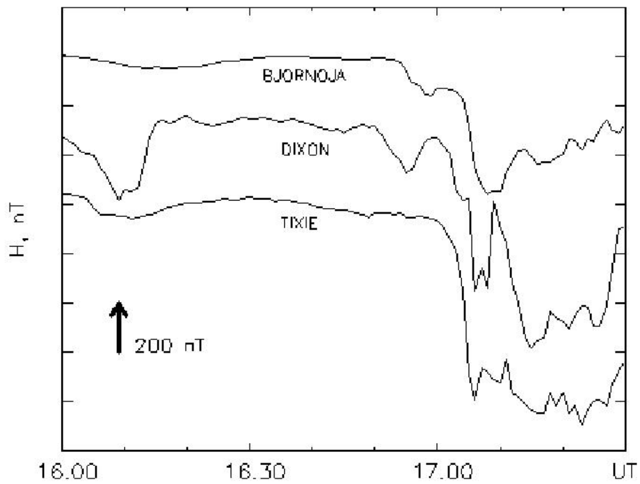

Fig 1. Magnetograms of the auroral station, 24.01. 1991

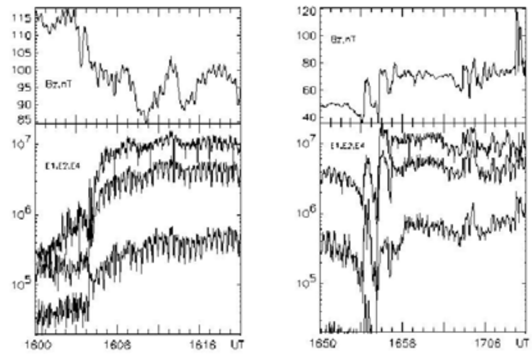

Fig 2. CRRES measurements, 24.01.1991 during PB (left) and AB (right). Top panels, Bz-component of the magnetic field, bottom panels, electron channels 20-30, 30-40, 50-60 keV

<u>High-energy electron</u> data are shown by Figure 2 together with CRRES magnetometer data. Electrons intensity enhancements with E > 20 кэВ at 16 and 17 UT data are comparable, clear difference is only in a temporal structure. Substorm onset consists on several activations accompanied by magnetic field dipolarization. It is important, that after the first activation local magnetic structure returned partially to the taillike stretching and only after the third activation dipolarization became final. During PB electron time profiles were smooth and with a single step.

<u>High-energy ions.</u> Figure 3 presents EPAS CRRES ion data for several energy channels. The PB enhancement involves only less energitic (30-70 keV) channels and was much weaker than the AB enhancement, which involves (50-250 keV) ions. During AB the ion increase went before the electron injection and dipilarization as in [Kozelova et al., 1998, Lazutin et al., 2002]. During PB, larger ion increase was delayed.

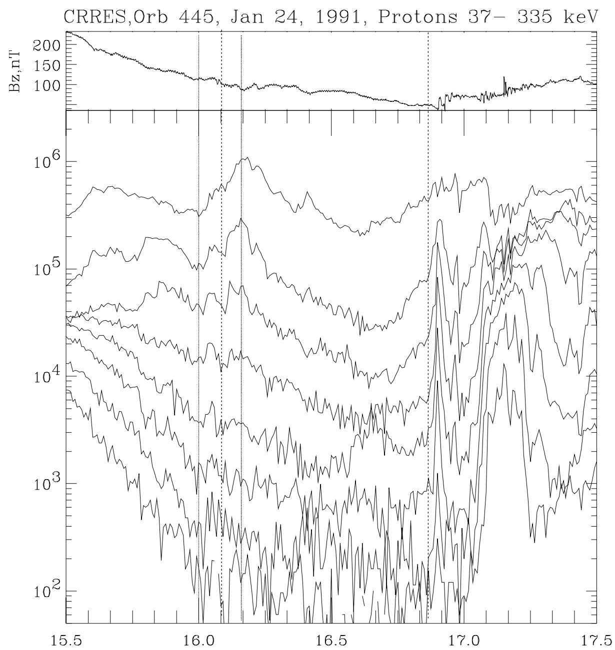

Fig 3. Energetic ions, 24.01.1991, CRRES

<u>Low-energy particles.</u> Of all low-energy data most pronounced and most important are field-aligned electron variations. Figure 4 shows the intensity variations for two energy ranges. Field-aligned electron precipitation and acceleration is typical for substorms, indicating current wedge formation. Both PB and AB are accompanied by field-aligned electron fluxes, the difference between them being in the electron energy: less than 400 eV during PB and

600-1000 eV for AB. These fast increases of electron field-aligned flux are observed around the moments when the perpendicular flux of ions (and pressure) increases as in [Lazutin et al., 2007].

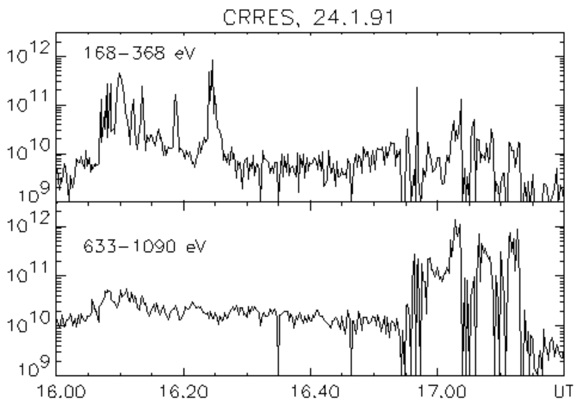

Fig 4. Field-align electron time profiles, CRRES, 24.01.1991

Discussion

There are two main approach to the description of substorm phenomena: tail reconnection model and alternative models which attempt to associate the substorm onset with the processes in quasitrapping region of the magnetosphere. It is obvious that in our case CRRES was in a quasitrapping region and that no indications of the influence of the magnetotail trigger was registered. A sudden brightening of an auroral arc must result from a sudden increase of precipitating electron flux in the keV energy range. It is related with the plasma pressure gradients and field-aligned currents. The magnetosphere-ionosphere coupling plays a crucial role in substorm development. Pseudobrekups are instances when the substorm onset criterion is met but the ionospheric condition is not favorable for current diversion from the magnetosphere to establish the substorm current wedge.

Table presents the comparison of the main effects found in our study or known before.

Table. Comparison of three types of disturbances by the different accompanying effects.

Effect	**Breakup**	**Pseudobreakup**	**Weak substorm**
Pi2	yes	Yes	yes
Magnetic bay, Ae	big	Small	moderate
Dipolarization	big	Big	small
Energetic electrons	many	Many	moderate
Energetic ions	many	Small	small (?)
Expansion	big	Negligible	moderate
Field-align electrons	many	Small	moderate

Our PB differs from the ordinary weak substorms by the sufficient developed growth phase and the adequate degree of the following dipolarization and consequently sufficiently high flux of the freshly accelerated energetic electrons. Two positions of the difference of the PB from the substorm onset are important. First one is the development of the dipolarization, which is steplike during substorm onset and one-step during PB. We can suppose that PB use almost all the accumulated energy, or by other words, the PB changes magnetosphere configuration to the more stable state. Koskinen et al. [1993], Ohtani et al. [1993] found, that after PB the growth phase started again and at least during 20 minutes no activation were observed. That supports our supposition that PB spend all the accumulated energy which made future expansion impossible.

As a second difference we found lower field-aligned (perpendicular) flux and lower energy for the electrons (ions) during the PB as compared with substorm onset. Less intensive electron flux may mean less favorable ionospheric condition for substorm development. In [Kan et al., 1988], two criteria for expansion onset are established: the polar cap potential must exceed a threshold value and the convection reversal region (with upward field-aligned currents) must overlap with the poleward gradient of the diffuse auroral conductance belt in the midnight sector. Most powerful inverted V structure at the equatorial boundary of the upward field-aligned current can be considered as onset location [Antonova, 2002, 2006].

The ion dynamics in the quasitrapping region plays a leading role in the preparation and development of the substorm. During the activations input of the high-energy ions to the plasma pressure became important. Increase of the ion intensity before the dipolarization was found to be necessary element for the final increase of the plasma pressure and preparation of the onset instability [Lazutin et al., 2007].. It seems that enhancement of the energetic protons during PB event was enough to prepare the onset instability but unsufficient for the following activations.

As a conclusion we can outline particularities of the pseudobreakups as following: with a low intensity of the auroral activation and field-aligned flux of low energy electrons which are responsible for that, the flux and energy of the accelerated ions also are small and unable to create conditions for the following activation. At the same time the intensity of the accelerated energetic electrons and also the degree of the magnetic field dipolarization are large. As a consequence the local magnetic configuration became more stable and new activation became possible only after sufficient interval of the removed growth phase.
That properties differs pseudobreakup from normal breakups and weak substorms.

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