EVIDENCE OF NONADIABATIC ELECTRON HEATING AND COOLING THROUGH A SELF-CONSISTENT QUASI-PERPENDICULAR SHOCK

Savoini Ph.(1), B. Lembège(2) and V. Krasnoselskikh(3)

(1) Philippe Savoini, CETP/UVSQ, 10-12, Avenue de l'Europe, 78140 Vélizy (France)
(e-mail: Philippe.SAVOINI@cetp.ipsl.fr)

(2) As (1) above, but (e-mail: Bertrand.LEMBEGE@cetp.ipsl.fr)

(3) Vladimir Krasnoselskikh, LPCE/CNRS, 3a, Avenue de la recherche scientifique, 45071 Orléans la Source, (France)
(e-mail□ vkrasnos@odyssee.cnrs-orleans.fr)

ABSTRACT

Results of the previous poster (n° 1494) have provided sets of complementary diagnostics allowing to identify nonadiabatic from adiabatic electrons crossing the front of a quasi-perpendicular and supercritical collisionless shock. These include *(i)* test particles approach based on individual electrons and *(ii)* test cubes approach. Both approaches allow to include the velocities phase effects. The aim of the present study is an extensive and statistical estimate of the relative percentage of nonadiabatic/adiabatic electrons and of the resulting heating versus the initial electron velocities phase. Electrons are initially released in the Solar wind frame at the same upstream location from the shock front; all electrons are distributed as a spherical shell in the velocity space with a common thermal velocity (radius of the shell is V_{th} = 1.04, in normalized parameter). All test particles interact with the same shock wave but do not see the same shock profile (according to the velocity phase),and in particular the electric field gradient in the first part of the ramp;this last quantity plays a major role for discriminating nonadiabatic from adiabatic electrons. As defined in poster 1494, a nonadiabatic electron is characterized by some deviation of the quantity Q (herein $Q < -0.1$) in the time range where this gradient is positive (first part of the ramp).

Statistical results show that nonadiabatic electrons are associated with a Q lying in the range $-0.13 > Q > -0.4$. Their other characteristics when they hit the shock wave are: *(i)* pitch angles in the range $135° \leq □_{vB} \leq 180°$ (in contrast with adiabatic electrons where $□_{vB} < 130°$), *(ii)* high parallel acceleration ($|P_{//}| > 0.7$) in contrast with reduced acceleration for adiabatic electrons ($|P_{//}| < 0.6$) *(iii)* in the velocity space, most of them are localized along the $B_{upstream}$ direction (anti-parallel direction) while adiabatic electrons are more localized in the perpendicular plane. A general feature is that nonadiabatic electrons spend less time in the ramp than adiabatic ones.

One striking feature is that two populations of nonadiabatic electrons can be identified within the first part of the shock ramp: *(i)* a fraction suffers a small parallel acceleration ($□P_{//}$ ~0.5) and a small Y-drift ($□Y \leq 11$) hereafter named "heated" population, while *(ii)* another fraction suffers a high acceleration ($□P_{//}$ > 0.55 -> 0.9) and a large Y-drift ($□Y \geq 15$) herafter named "cool" population. *A posteriori* relative good agreement is obtained with the downstream state of these particles (conservation of □). More particularly, the "cool" ("heated") population is characterized by a decrease (increase) of the □ parameter measured in the downstream region. Moreover, statistical results follow qualitatively the theoretical predictions of [2] and show an "irreversible" inflation of the velocity space volume (divergence of trajectories in velocity space) even for adiabatic particles; however, some quantitative discrepancies with theory occur which will be discussed.

Present results may be of importance for accounting for electron heating and/or overheating through the shock ramp evidenced in previous ISEE data; these also define some guidelines for analysing new experimental data issued from CLUSTER-2 mission.

NB: This work is supported by ISSI (Bern, Switzerland)

REFERENCES

[1] Cole K. D., Effects of crossed magnetic and spatially dependent electric fields on charged particle motion, *Planet. Space. Sc.*, 24, 518, 1976.

[2] Balikhin M.A. and V.Krasnosselskikh and L. J. C. Woolliscroft and M. A. Gedalin, A study of the dispersion of the electron distribution in the presence of E and B gradients: Application to electron heating at quasi-perpendicular shocks, *J. Geophys. Res.*, 103, 2029--2040, 1998.