BASIC MECHANISMS INVOLVED IN THE ADIABATICITY BREAKDOWN OF ELECTRONS TRANSMITTED THROUGH A QUASIPERPENDICULAR SHOCK

B. Lembège[1] and Ph. Savoini[2]

(1) Bertrand Lembège, CETP/UVSQ, 10-12, Avenue de l'Europe, 78140 Vélizy (France)
(e-mail: Bertrand.LEMBEGE@cetp.ipsl.fr)
(2) As (1) above, but (e-mail: Philippe.SAVOINI@cetp.ipsl.fr)

ABSTRACT

Breakdown of adiabaticity of electrons crossing a collisionless shock front is analysed in details. Previous works use to evidence the adiabaticity breakdown in terms of jump of magnetic momentum between upstream and downstream regions. However, such an approach does not provide any information on the physical mechanims responsible for this breakdown within the shock front itself. The purpose of this analysis is to identify these mechanisms within the front with the help of numerical simulations. The shock of concern herein is quasiperpendicular and in supercritical regime. Results are issued from test particles simulations based on the use of all fields components issued from 2-D self consistent full particle simulations and of spherical shell velocity distributions of incoming electrons cubes. Test electrons are launched from the same position upstream from the shock front, so that any difference between will result from their relative phases in the velocity space.

Present analysis shows that adiabaticity deviation takes place locally within the first part of the ramp where the gradient of the electrostatic field is positive in good qualitative agreement with theory of [1]. Indeed, this theory predicts that when this positive gradient seen by an electron crossing the shock front is large enough, the electron gyromotion is strongly affected and adiabaticity breakdown may take place [2].

Presently, two appropriate sets of complementary diagnostics respectively based on (i) the individual electron dynamics (where the electron is at the barycenter location of the cube), and (ii) on the expansion of the different cubes distributed on the shell, have been defined in order to identify and to estimate this deviation. In particular, adiabaticity deviation is identified when quantities $Q=1-\square_{real}/\square_{ce}$ (where $\square_{real}$ and $\square_{ce}$ are respectively the real gyration frequency measured from the time history of the perpendicular electron momentum and the magnetic gyrofrequency), the y-deviation extent, and the parallel momentum strongly depart from their upstream value when the electron crosses the first part of the front ramp. The second set confirms that the cube expansion always establishes and mainly takes place in the direction perpendicular to the local magnetic field within the first part of the ramp; for a nonadiabatic electron, some parallel expansion occurs. However, although a qualitative agreement in obtained between present simulation results and theoretical expectations, some quantitative discrepancies are evidenced with results of [1], which will be discussed.

REFERENCES

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