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A three-dimensional hybrid code to model the particle dynamics in the magnetotail current sheet

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In this work we present a description of a stationary three-dimensional hybrid code with ions represented by particles and electrons by a massless fluid. We use this code to study how electrons influence the ion dynamics in the magnetotail current sheet.
We solve the ion equations of motion in assigned electric and magnetic fields typical of the magnetotail configuration, and ion distribution function moments are obtained (density, current density, parallel and perpendicular temperature and so on).
Plasma is in a quasi-neutral condition and we determine the electron bulk velocity perpendicular to the magnetic field from the electron momentum equation with $m_e \rightarrow 0$ and without collisions. We take into account the electron pressure term, which we calculate using the simple adiabatic or isothermal equation of state.
The parallel component of the electron bulk velocity is derived from the electron continuity equation which we solve by using a semi-lagrangian method, which consists in integrating backwards the magnetic filed lines to a plane where the value of the above physical quantity is well known. In this way, we are able to calculate the total current density J as the sum of ion contribute and electron one.
From the Ampere law, we determine the new magnetic field, which we interpret as a correction of the input one, applying FFT algorithms, and from the stationarity condition of the electric field and from the equation of state, we are able to calculate the new components of the electric field, using the semi-lagrangian method described above, with the condition that the new electric field is equal to the input one on the boundaries away from the neutral sheet.
The next step is to run the ions in these new fields and see how the particle dynamics changes.
We vary the value of the magnetic component normal to the neutral sheet, the ion in-

jection energy and the anisotropy parameter ϵ in order to study how these parameters influence the whole dynamics in the magnetotail current sheet.