A predictor-corrector schema based upon Boris schema for the integration of the equation of motion of charged particles : Application to the Earth's inner magnetosphere

*Gerard Marcel CHANTEUR[1]

1.Ecole Polytechnique, Palaiseau, France

A lot of numerical schemes are available for integrating the equations of motion of a charged particle in an electromagnetic field. The schema proposed by Boris (1970) is one of the most remarkable due to its simplicity and accuracy and hence is widely used in numerical plasma physics. Although being not a leap-frog schema due to the dependence of the electromagnetic force upon the velocity, it has a structure reminiscent of the leap-frog which imposes to stop and restart the integration in order to change the time step. Hence the original Boris' schema does not allow a continuous adaptation of the time step. Changing the time step during self-consistent numerical simulations would be difficult, if not practically impossible, but it may be of interest for test particle simulations. We present a predictor-corrector schema making use of the acceleration substep of Boris' algorithm which allows to vary continuously the time step. We have also designed a procedure for the automatic control of the time step. Applications to the motion of energetic particles in the terrestrial magnetosphere will be presented.
Reference
Boris, J.P., ''Relativistic Plasma Simulation - Optimization of a hybrid code'', in Proceedings of the 4th Conference on Numerical Simulation of Plasmas, pp 3-67, NRL, Washington, Nov. 1970.

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