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Kinetic mecanisms underlying the fluid description of the ions in magnetic reconnection

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Because of its ability to transfer the energy stored in the magnetic field, together with the breaking of the flux freezing constraint, magnetic reconnection is considered to be a very important phenomenon in plasma physics. When it happens in a collisionless environment such as the terrestrial magnetosphere, the phenomenon should, a priori, be modeled within the framework of kinetic physics. The evidence of kinetic features has incidentally for a long time, been shown by researchers with the help of both numerical simulations and satellite observations at electron and ions scales. However, most of our understanding of the process comes from the more intuitive fluid interpretation used with simple closure hypothesis which do not include kinetic effects.

To what extent are these two separate descriptions of the same phenomena related ? What is the role of kinetic effects in the averaged/fluid dynamics of magnetic reconnection ? This work intends to answer these questions for the proton population in the particular case of approximatly steady state antiparallel merging. We show that one cannot assume, as is usually done, that the acceleration of the ion flow is only due to the JxB force. Our 2D hybrid simulations indeed reveal that it is the result of the slight unbalance of the opposed electric and pressure forces, located on the separatrices. This important pressure force does not come from the compression of the plasma density, as could be observed using simple closure equations, but is rather strongly related to the particle dynamics. Indeed, on the kinetic point of view, the particles are accelerated in potential well whose spatial divergence is responsible for an organized mixing in phase space, which in return, build the tensorial structure of the pressure important for the average momentum flux. An energy budget analysis of the same simulation, shows consistently with the important role of the pressure force for the acceleration, that a dominant part of the incoming Poynting flux is transfered to the thermal energy flux, which cannot be omitted either in analytic modeling.