

# Ion runaway acceleration during magnetic reconnection in MAST

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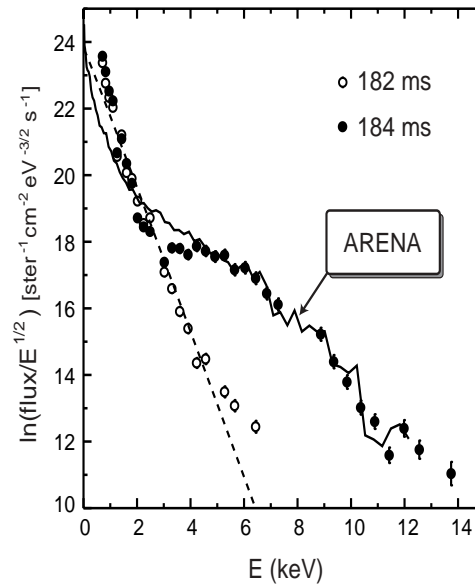
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In MAST, suprathermal ions are routinely observed by the neutral-particle analyser in Ohmic discharges with internal reconnection events. In each such event, a high-energy tail is formed in the ion distribution function, which then relaxes back towards a Maxwellian on the collision time scale. In this paper a kinetic theory is developed to explain these observations in terms of runaway ion acceleration in the parallel electric field induced by the reconnection – a phenomenon predicted theoretically by Furth and Rutherford in 1972 but not commonly noted in tokamaks [1]. The observed ion acceleration in MAST is reminiscent of observations of ion heating and tail formation in reversed field pinches, and could shed light on this long-standing puzzle.

The electric field is calculated from a simple model of reconnection events based on magnetic helicity conservation, which successfully predicts their main characteristics: an increase in total plasma current, a broadening of the current profile, and a negative voltage spike at the plasma edge. The effective electric field acting on the plasma ions is then calculated using tools from neoclassical theory to account for the effects of impurity ions and toroidicity, these being crucial for achieving ion acceleration. Finally, the ion distribution function is calculated, both analytically and numerically. The analytical theory is a generalisation of a classic runaway calculation of Kruskal and Bernstein so as to account for the fact that only a finite time is available for ion acceleration. The numerical solution is obtained from the ARENA Monte Carlo code that solves the orbit-averaged kinetic equation in toroidal geometry [2]. These simulation results, which are obtained using no “free” parameters, are in excellent agreement with the experimental energy spectra of fast ions.



*Ion distribution function before and after a reconnection event, as measured by the NPA and simulated with the ARENA code.*

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[1] H. P. Furth and P. H. Rutherford, Phys. Rev. Lett. **28**, 545 (1972).

[2] P. Helander, L.-G. Eriksson, and F. Andersson, Phys. Plasmas **7**, 4106 (2000).