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Ion acceleration at collisionless shocks

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Recent results of large 2D and 3D hybrid (kinetic ions-fluid electrons) first-principles simulations of ion acceleration at non-relativistic collisionless shocks are presented.
Proton acceleration, magnetic field generation, and injection and acceleration of ions with arbitrary mass-to-charge ratios are characterized in detail as a function of the shock parameters, such as inclination and Mach number. Results are used to test and complement the classical theory of diffusive shock acceleration.
Moreover, with the same ab-initio techniques, I investigate the re-acceleration of pre-energized "seed" particles and discuss the relevant plasma instabilities driven by energetic ions, which lead to a significant rearrangement and amplification of the background magnetic field.