Magnetic reconnection propulsion

Fatima Ebrahimi

Princeton Plasma Physics Laboratory and Princeton University

A new concept for the generation of thrust for space propulsion, an Alfvenic reconnecting plasmoid thruster, is introduced (F. Ebrahimi, featured article in the Journal of Plasma Physics, Volume 86, Issue 6, December 2020). Energetic thrust is generated in the form of plasmoids (confined plasma in closed magnetic loops) when magnetic helicity is injected into an annular channel. Using a novel configuration of static electric and magnetic fields, the concept utilizes a current-sheet instability to spontaneously and continuously create plasmoids via magnetic reconnection. The magnetic reconnection process here converts magnetic energy of the applied fields to kinetic energy of the plasmoids, accelerating them to a velocity of tens to hundreds of km/s, adjustable by varying the magnetic field strength. The qualitative experimental evidence of plasmoid formation demonstrated during transient coaxial helicity injection in NSTX was first predicted by global MHD simulations (Ebrahimi & Raman Physical Review Letters 114, 205003 2015), and has inspired this thruster concept. This concept combines magnetic helicity injection with axisymmetric fast magnetic reconnection, and is extensively explored via three-dimensional extended MHD NIMROD simulations. The plasmoids carry large momentum, leading to a thruster design capable of producing thrusts from tenths to tens of newtons. The Alfvenic plasmoid thruster would occupy a complementary part of parameter space with little overlap with existing thrusters, and be suitable for long-distance travel with high Delta-v, including the solar system beyond the Moon and Mars.