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Theoretical and experimental studies of high-beta plasmas formed by odd-parity rotating magnetic fields[1]

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Hamiltonian simulations of ion and electron heating by odd-parity rotating magnetic fields applied to FRC plasmas have predicted rapid heating of both electrons and ions to multi-keV temperatures, even at low relative RMF strengths. Both the onset of heating and saturation of energy have been explained by perturbation analysis in stochastic theory. These simulations assumed full RMF penetration to the major axis and collisionless particle trajectories, the latter expected in fusion reactor. However, most present RMF/FRC experiments do not achieve full RMF penetration and operate in a low-temperature collisional regime, far from fusion-reactor conditions. Recent experiments at Princeton, which employ commercial off-the-shelf hardware and non-invasive diagnostics and which use, for the first time in FRC research, remote divertor chambers, have achieved a thousand-fold reduction in collisionality to below 0.001, volume-averaged beta above 0.5, electron temperatures above 200 eV, and full penetration of the RMF while avoiding the radiation barrier encountered by other RMF/FRC experiments. Comparisons between theory and experiment show the important role of infrequent collisions, particularly with neutrals. Motivations for a superconducting next-step FRC and design considerations for a car-sized practical FRC reactor will be described.

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