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Wave induced supersonic rotation in mirrors[1]

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Wave-particle interactions in **E**x**B** supersonically rotating plasmas feature an unusual effect: particles are diffused by waves in both potential energy and kinetic energy [1]. This wave-particle interaction generalizes the alpha channeling effect, in which radio frequency waves are used to remove alpha particles collisionlessly at low energy. In rotating plasmas, the alpha particles may be removed at low energy through the loss cone, and the energy lost may be transferred to the radial electric field. This eliminates the need for electrodes in the mirror throat, which have presented serious technical issues in past rotating plasma devices. A particularly simple way to achieve this effect is to use a high azimuthal mode number perturbation on the magnetic field [2]. In the rotating frame, this perturbation is seen as a wave near the alpha particle cyclotron harmonic, and can break the azimuthal symmetry and magnetic moment conservation without changing the particle's total energy. The particle may exit if it reduces its kinetic energy and becomes more trapped if it gains kinetic energy, leading to a steady state current that maintains the field. Simulations of single particles in rotating mirrors show that a stationary wave can extract enough energy from alpha particles for a reactor to be self-sustaining. Rotation can also be sustained by waves in plasmas without a kinetic energy source. This type of wave has been considered for plasma centrifuges used for isotope separation [3].

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[3] A. J. Fetterman and N. J. Fisch, *Plasma Sources Sci. Tech.* **18**, 045003 (2009).

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[2]Work done in collaboration with Nathaniel Fisch