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Magnetized plasmas for high-throughput mass separation

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Rotation in magnetized plasmas holds great promise for a variety of applications. Under some conditions, rotation is for instance believed to mitigate or suppress turbulence. Recently, it has been suggested that rotation could be used to confine particles in toroidal geometry without the need for a poloidal magnetic field [1], and that this scheme could improve efficiency as compared to tokamaks. Yet another promising application of plasma rotation is separation. At its roots, plasma separation can be thought of as differential magnetic confinement, a generalization of magnetic confinement. Advancing plasma separation science hence shares many scientific issues with magnetic confinement. Foundational work on plasma mass separation, i. e. separation based on atomic mass in a plasma, was motivated by isotope separation. This typically involves separating elements with small mass difference at relatively low throughput. On the other hand, it has been shown in the last decade that separating elements based on mass at high throughput could prove particularly advantageous for a variety of high societal impact applications, including nuclear spent fuel reprocessing, nuclear waste cleanup and rare earth elements recycling. Yet, separation mechanisms which are efficient at low throughput often do not scale up to high throughput separation. For instance, many separation concepts rely on collisionless operation, which is not practical at high throughput. New separation mechanisms which are efficient at high throughput are therefore called for. One promising option is rotating plasma configurations, in which centrifugal effects can be supplemented by electric and magnetic forces to produce separation. In this talk I will review some of the fundamental physics challenges which remain to be addressed to enable mass separation in rotating plasma configurations at high throughput. [1] Rax, J. M., Gueroult, R. and Fisch, N. J., Phys. Plasmas, 2017, 24, 032504