Confinement in a Wave-Driven Rotating Plasma Torus

N. J. Fisch\textsuperscript{a}, I. E. Ochs\textsuperscript{a}, R. Gueroult\textsuperscript{b}, and J. M. Rax\textsuperscript{c}

\textsuperscript{a}Department of Astrophysical Sciences, Princeton University, Princeton, NJ 08543, USA
\textsuperscript{b}LAPLACE, Université de Toulouse, CNRS, INPT, UPS, 31062 Toulouse, France
\textsuperscript{c}Université de Paris XI - Ecole Polytechnique, LOA-ENSTA-CNRS, 91128 Palaiseau, France

Single particle confinement can be achieved in a torus with a toroidal magnetic field and a radial electric field over the minor cross section. This configuration produces an azimuthal rotational transform through an $E \times B$ drift that acts very much like the confinement produced in a tokamak, except that here the rotational transform is produced by a poloidal magnetic field. In either case, reactive energy storage, whether in the fields or in the plasma rotation, is necessary. Also, in either case it can be imagined that external wave power can injected to maintain in steady state the fields that produce the rotational transform. The steady state plasma confinement device, comprising a toroidal magnetic field and a radial electric field maintained by waves, has been called the Wave-Driven Rotating Torus or WDTR for short [1].

Importantly, it has been shown recently that, compared to a steady state tokamak, the WDTR might, for large enough aspect ratios, incur less power dissipation and require less reactive energy storage [1]. However, as described, the WDTR guarantees only single particle confinement. It remains to investigate how the plasma can be in force balance in the major radial direction. It also remains to explore instabilities, transport and magnetic equilibrium, as well as various optimizations. It is anticipated that the configuration will be maintained by pushing charge across field lines, like in alpha channeling [2], but in a rotating plasma [3]; however, it remains to identify the specific waves that might best accomplish this effect.

The significant upside potential of this configuration motivates addressing these uncertainties. Apart from advantages with respect to the circulating power to operate this device, note that any disruption of the operation will not generate the large electric fields that create the damaging runaway electrons in tokamaks. Furthermore, in the case of holding the plasma at negative rather than positive potential to create the rotation, the alpha channeling may be aided by what amounts to direct energy conversion as alpha particles climb a steep potential to leave the device.

References