Energy confinement time in a magnetically confined thermonuclear fusion reactor

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The single most important scientific question in fusion research may be confinement in a fusion plasma [1]. A recently-developed theoretical model [2] is reviewed for the confinement time of ion kinetic energy in a material where fusion reactions occur. In the theoretical model where ion stopping was considered as a key mechanism for ion kinetic energy loss, an estimate was obtained for the confinement time of ion kinetic energy in a D-T plasma - and found to be orders of magnitude lower than required in the Lawson criterion. As ions transfer their kinetic energies to electrons via ion stopping and thermalization between the ions and the electrons takes place, spontaneous electron cyclotron radiation is identified as a key mechanism for electron kinetic energy loss in a magnetically confined plasma. The energy confinement time is obtained and found in agreement with measurements from TFTR [1] and Wendelstein 7-X [3]. An advanced Lawson criterion is obtained for a magnetically confined thermonuclear fusion reactor.

1. D.M, Meade, "TFTR Twenty Year Perspective," Proceedings of 17th IEEE/NPSS Symposium on Nuclear Engineering, Vol. 2, pp.10-17 (1998).
2. C. Chen, J.R. Becker, and J.J. Farrell, "Confinement Time of Ion Kinetic Energy in a Controlled Nuclear Fusion System," Proceedings of 47th European Physical Society Conference on Plasma Physics, P1.4006 (2021).
3. T. Klinger, et al., "Overview of first Wendelstein 7-X high performance operation," Nucl. Fusion **59**, 112004 (2019).