Sizing up plasmas using dimensionless parameters

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Abstract

This paper reviews the application to magnetic-confinement fusion experiments of dimensional analysis, which holds that the behavior of physical systems can be determined from the scaling of phenomena with the set of dimensionless parameters that embody the governing physics. This paper begins by explaining the two most well-known approaches to dimensional analysis, and shows that the principle of similarity has been demonstrated in high temperature plasmas of different physical size. Next, the measured dependences of cross-magnetic field transport and edge plasma characteristics on dimensionless parameters are examined. These dimensionless parameter scans are generally in good agreement with drift wave models of turbulent transport (i.e., microturbulence), although some discrepancies remain. Finally, the benefits of incorporating dimensional analysis into the extrapolation of plasma behavior from present-day experiments to future burning plasma devices are discussed. The experiments reviewed in this paper have greatly improved our understanding of the underlying physics of many plasma phenomena.