REVIEW OF TOKAMAK RESEARCH*

R.D. Stambaugh

General Atomics, P.O. Box 85608, San Diego, California 92186-5608

There has been great progress recently in understanding the basic physics of tokamaks and in the level of tokamak performance. Advances in measurements and theory have led to a situation in which we can calculate most processes of interest, the exception being cross field transport. However, gyrokinetic and gyrofluid code predictions are being tested against detailed measurements of the relevant profiles and turbulent fluctuations. Sheared E×B flow as a means of stabilizing microturbulence has been discovered and resulted in ion transport at neoclassical predictions. The cutting edge of transport research is now in active control of edge and core transport barriers. Plasma equilibrium theory is well understood and extensively used to control highly shaped plasmas. Profile effects on ideal stability have been verified and stability limits can be accurately predicted. High performance tokamak plasmas are now often limited by non-ideal instabilities such as the resistive wall mode (critically important in other MFE concepts) and neoclassical tearing modes. Successful methods of heating and current drive for steady-state have been developed. The total current has been driven by the self-generated bootstrap current and rf or neutral beams for times up to two hours. The forefront of this research is in controlling the current profile for optimal stability and transport. New measurements and modeling codes for the plasma edge and divertor have revealed the physics of high density recombining plasma states that offer a power and particle exhaust solution. The leading challenge in this area is to bring together the high density divertor solution with the low density core plasmas needed for current drive. Fast particle driven instabilities have been indentified and the regimes of occurrence agree well with predictions. Significant fusion power has been produced, alpha particles confined in accordance with theory, and measurable alpha heating of electrons verified. The scientific basis developed for the tokamak indicates our readiness to move forward to the next phases of burning plasma and steady-state research.

*Work supported by U.S. Department of Energy under Contract No. DE-AC03-99ER54463.