Plasma Beta Enhancement in Reactors from the Thick Conducting Blanket

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Reactor blankets for breeding tritium in a tokamak reactor often have considerable net conductivity, are thick, and are close to the plasma. Here, we give calculations which indicate a strong potential that their stabilizing effect can lead to a doubling of tokamak reactor beta. We give calculations in simplified plasma geometry, but including crucial realistic complexities of the conducting shell provided by a blanket: it is thick, toroidally segmented, non-axisymmetric, and has considerable non-conducting regions. We find that blankets can provide a much better stabilizing shell than the vacuum vessel in present tokamak experiments, and the dedicated shell which has been assumed in reactor studies to date. Approximate calculations indicate that it appears possible to extend the practical elongation of a reactor to between 2.5 and 3, rather than values ~ 2 as has been assumed in the past. Studies for ARIES reactor designs[1] have shown that increasing elongation to this range can enable roughly a doubling of beta for reactor scenarios, but this has been considered impossible before now due to unacceptable engineering requirements for a dedicated stabilizing shell. Our results indicate that a dedicated shell appears superfluous for many blanket designs, and the net conductivity of the blanket can enable such high elongations. Conceptual blanket designs will be examined similar to those which are being considered for the ITER Test Blanket Module program; some are better than others as stabilizing shells. With suitable lamination of the magnet shield it also appears possible for feedback signals to penetrate through the blanket and stabilize resistive wall modes for axisymmtric modes and kink modes (in simplified plasma geometries and models). Thus, both physicists and engineers should recognize that blankets have an unrecognized potential for physics benefits which could significantly improve the attractiveness of fusion reactors. This strongly motivates future studies to quantitatively examine these effects with realistic plasma equilibria.[2]

[1]C.E. Kessel, T.K. Mau, S.C. Jardin, F. Najmabadi, Princeton Plasma Physics Laboratory Report PPPL-3573

2 L.-J. Zheng, M. Kotschenreuther, M.S. Chu, M. Chance, A. Turnbull, this conference