Equilibrium and Stability for the ARIES Compact Stellarator Reactor*

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Equilibrium and ideal magnetohydrodynamic (MHD) stability studies are reported for Compact Stellarator reactor equilibria. The linear MHD stability β limit was determined using the TERPSICHORE [1] code for a sequence of uniformly scaled pressure equilibria, based on a scaled-up three-period NCSX configuration, with all other parameters fixed. With a moderately placed conformal stabilizing shell at twice the plasma minor radius, robustly stable equilibria up to 6% are achievable. A two-period variant, the MHH2 stellarator, with good quasi-axisymmetry comparable to that in a tokamak with toroidal ripple, for which the β limits are only slightly lower but which has some engineering advantages is also considered. Several general issues, important in interpreting the results, are addressed. Progress in extending the numerical range of applicability of the TERPSICHORE code is discussed. Also, recent experiments on W7-AS and LHD raise questions as to the applicability of linear ideal MHD stability in stellarators since the predicted stability limits appear to be significantly exceeded. A context for resolving this conflict, consistent with experience from tokamak stability, is discussed. For example, there are reasonable theoretical justifications for ignoring the local stability criteria. Also, several common assumptions about the experimental discharge equilibria used for the global MHD stability predictions may be questionable and routine measurements of the pressure and ι profiles at finite β are needed. The nonlinear consequences are also crucial in interpreting the stability results and non-ideal contributions need to be explored. Nonlinear stability is analyzed using the NSTAB [2] code to compute weak solutions for fixed boundary 3-D equilibria, with highly resolved discontinuities to effectively simulate current sheets and island chains. Nonlinear stability is tested by applying a mountain-pass theorem when equilibria exist. This yields β limits for LHD and W7-AS in reasonable agreement with the measured values. By comparing these nonlinear predictions with the linear predictions, a good heuristic understanding of the expected consequences of predicted linear instabilities can be developed.

[1] A. Ardelea, W.A. Cooper and L. Villard, Plasma Phys. Control. Fusion **40**, 1679 (1998).
[2] P.R. Garabedian, Plasma Phys. Control. Fusion **39**, B129 (1997).

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