Experimental tests of linear and nonlinear 3D equilibrium models in DIII-D

J.D. King[1,2], E.J. Strait[2], S.A. Lazerson[3], N.M. Ferraro[2], N.C. Logan[3], S.R. Haskey[4], J.-K. Park[3], J.M. Hanson[5], M.J. Lanctot[2], Y.Q. Liu[6], R. Nazikian[3], M. Okabayashi[3], C. Paz-Soldan[2], D. Shiraki[7], and A.D. Turnbull[2]

[1]*Oak Ridge Institute for Science Education, Oak Ridge, Tennessee 37830-8050, USA*

[2]*General Atomics, P.O. Box 85608, San Diego, California 92816-5608, USA*

[3]*Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, New Jersey 08543-0451, USA*

[4]*Plasma Research Laboratory, Research School of Physical Sciences and Engineering, The Australia National University, Canberra, ACT 0200, Australia*

[5]*Columbia University, 2960 Broadway, New York, New York 10027, USA*

[6]*Culham Centre for Fusion Energy, Culham Science Centre, Abingdon, Oxfordshire, OX14 3DB, United Kingdom*

[7]*Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831, USA*

email of first author: kingjd@fusion.gat.com

Abstract. DIII-D experiments using new detailed magnetic diagnostics show that linear, ideal magnetohydrodynamics (MHD) theory quantitatively describes the magnetic structure (as measured externally) of three-dimensional equilibria resulting from applied fields with toroidal mode number $n = 1$, while a nonlinear solution to ideal MHD force balance, using the VMEC code, requires the inclusion of $n \geq 1$ to achieve similar agreement. These tests are carried out near ITER baseline parameters, providing a validated basis on which to exploit 3D fields for plasma control development. Scans of the applied poloidal spectrum and edge safety factor confirm that low-pressure, n =1 non-axisymmetric tokamak equilibria are determined by a single, dominant, stable eigenmode. However, at higher beta, near the ideal kink mode stability limit in the absence of a conducting wall, the qualitative features of the 3D structure are observed to vary in a way that is not captured by ideal MHD.

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