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Final Progress Report on

LARGE EXPERIMENT DATA ANALYSIS COLLABORATION

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Grant Period: November 15, 1997 through November 14, 1998

This is the third annual and final progress report on the current three-year Large Experiment Data Analysis Collaboration DOE grant DE-FG02-92ER54139. The funding level during this grant year was $150k. The participating personnel and their approximate degree of funded involvement in this research project has been as follows: J.D. Callen (PI: 10% during academic year, 1 summer month); C.C. Hegna (Asst. Sci., 25%); M.W. Kissick (postdoc, 11/97-3/98), T.A. Gianakon (postdoc, 15%, was on postdoc at Cadarache, France 4/98-6/98); and graduate students C. Ren (75% RA until 7/98 and then postdoc), and S.E. Kruger (25% RA). In addition, K.J. Comer, a graduate student who holds a DOE Magnetic Fusion Science Fellowship, participates in this research project. C. Ren completed his Ph.D. thesis entitled "A Study of Tearing Modes Using ECE from Tokamak Plasmas" in July 1998. He continues research on this grant as a postdoc on assignment at General Atomics in San Diego.

Neoclassical Tearing Modes [1, 2,4-9, 11, 12, 14, 15b, 15c, 16, 17, 20a, 20c, 20d, 20e, 21a, 21b, 22, 24]

Studies of neoclassical tearing modes have remained the dominant area of research on this grant. Our major role in their development was recognized through an invited paper at the 1998 Pittsburgh DPP-APS meeting [9,14] and through our inclusion as coauthors on some major TFTR [2,4,8] and DIII-D [5] papers. During this past year, prior work has been published on DIII-D experiment-motivated theories of stabilization of tearing modes via localized current-drive and heating [1] and on effects of geometry on these modes (elongation and triangularity effects should be small in DIII-D) [7], and on experimental studies of the imposed beta limits [5] and direct, internal measurements [6,15c,22] of the critical classical tearing mode stability parameter (delta-prime). Also, linear and nonlinear theory and computation studies of classical tearing modes via the "almost ideal MHD" constraint has been the subject of a number of meeting presentations [17,21b] and has recently been published [11]. Recent work has been concerned with developing a theoretical model [12,20a] for the magnitude of seed island perturbations due to

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geometrically coupled magnetic perturbations (e.g., ELMs or sawtooth crashes) and simulations thereof [20e], exploring the effects of external perturbations [16], development of a simulation model for flow shear effects [15b,20d], studies (initiated by M.S. Chu) of the effect of the combination of flow shear and perpendicular viscosity in distorting the magnetic island structure and producing the phase shift in ECE signals across a magnetic island [20c], simulations of feedback stabilization of tearing mode islands [21a], and exploring [24] what aspects of tearing modes need to be calculated for DIII-D.

Nonlocal Electron Heat Transport [3, 10, 15e, 18, 23]

Our continuing role in transient transport [18] and nonlocal electron heat transport [23] was recognized by an invited paper at the June 1997 EPS Berchtesgaden meeting which was published this past year [3]. In addition, further details of nonlocal electron heat transport, primarily on TFTR, have been the subject of meeting presentations [15e] and are being published [10]. Since Dr. Kissick left this research group for UCLA in April 1998 and Prof. Callen is in the process of transferring leadership of the TTF Transient Transport Working Group to Prof. Gentle (U. Texas), it is anticipated that this grant research area will be substantially diminished in the future.

Disruption Precursors [13, 15a, 15d, 19, 20b, 25]

Stimulated in large part by the excellent internal fluctuation diagnostics (primarily ECE and BES) for studying MHD modes in the interior of DIII-D [15a], we have begun work in a new area: disruption precursors induced by MHD modes being driven slowly through their ideal stability boundaries. In particular, we have constructed a new model for the temporal development of such precursors and shown that it provides a very good fit to DIII-D data [13,19,20b,25]. Also, we are in the process [15d] of developing codes for comparing the spatial profile of the disruption precursors with those predicted from the GATO ideal MHD instability code.

Grant-Related Publications

Journal Articles, Conference Proceedings Papers:

[1]* C.C. Hegna and J.D. Callen, "On the Stabilization of Neoclassical MHD Tearing Modes Using Localized Current Drive or Heating," Phys. Plasmas 4, 2940 (1997).

[2] J.D. Strachan,..., J.D. Callen et al., "TFTR DT Experiments," Plasma Phys. Control. Fusion 39, B103 (1997).

[3]* J.D. Callen and M.W. Kissick, "Evidence and Concepts for Non-local Transport," Plasma Phys. Control. Fusion 39, B173 (1997).

[4] K.M. McGuire,..., J.D. Callen et al., "Physics of High Performance Deuterium-Tritium Plasmas in TFTR," in Fusion Energy 1996 (IAEA, Vienna, 1997), Vol. 1, p. 19.

[5] R.J. LaHaye, J.D. Callen, M.S. Chu, S. Deshpande, T.A. Gianakon, C.C. Hegna et al., "Practical Beta Limit in ITER-Shaped Discharges in DIII-D and its Increase by Higher Collisionality," in Fusion Energy 1996 (IAEA, Vienna, 1997), Vol. 1, p. 747.

[6] C. Ren, J.D. Callen, C.C. Hegna, Z. Chang, E.D. Fredrickson, K.M. McGuire, G. Taylor, and M.C. Zarnstorff, "Measuring Delta-prime from Electron Temperature Fluctuations in the Tokamak Fusion Test Reactor," Phys. Plasmas 5, 450 (1998).

[7]* S.E. Kruger, C.C. Hegna, and J.D. Callen, "Geometrical Influences on Neoclassical Tearing Modes," Phys. Plasmas 5, 455 (1998).

[8] R.J. Hawryluk,..., J. Callen,..., M. Kissick et al., "Fusion Plasma Experiments on TFTR: A 20 Year Retrospective," Phys. Plasmas 5, 1577 (1998).

[9]* C.C. Hegna, "The Physics of Neoclassical Magnetohydryodynamic Tearing Modes," Phys. Plasmas 5, 1767 (1998).

[10] M.W. Kissick, J.D. Callen, E.D. Fredrickson, "Conditions and behaviour related to non-local electron heat transport" (to be published in Nuclear Fusion, June 1998).

[11] C. Ren, T.H. Jensen and J.D. Callen, "Nonlinear Tearing Mode Study Using The 'Almost Ideal Magnetohydrodynamics (MHD)' Constraint," Phys. Plasmas 5, 2574 (1998). Originally available as Report GA-A22751, January 1998.

Reports (in process of being submitted for publication):

[12] C.C. Hegna, J.D. Callen and R.J. La Haye, "Seed Magnetic Island Formation due to Geometrically Coupled Perturbations," UW CPTC 98-5, July 1998.

[13] J.D. Callen, C.C. Hegna, E.J. Strait, and A.D. Turnbull, "Growth of Ideal MHD Modes Driven Slowly Through Their Instability Threshold: Application to Disruption Precursors," GA Report currently being reviewed for publication.

Invited Talks:

[14]* C.C. Hegna, "The Physics of Neoclassical Magnetohydrodynamic Tearing Modes," Pittsburgh DPP-APS Meeting, 17-21 November 1997. (Published as [9] above).

Meeting Presentations:

[15] Oral Talks and Posters at Annual DPP-APS Meeting, Pittsburgh, PA, 17-21 November 1998:

a) dMopO1 9 "Stability Limits of DIII-D Discharges with Strongly Peaked Pressure Profiles," E.J. Strait,...K. Comer, C. Ren et al.

b)* dMopP1 27 "The Effect of Shear Flow on Neoclassical Tearing Modes," S.E. Kruger, C.C. Hegna, J.D. Callen

c) lWepP1 2 "Study of Tearing Modes on DIII-D by ECE Data Analysis," C. Ren, J.D. Callen, G. McKee, M. Jakubowski, R.J. Fonck, M.E. Austin, E.D. Fredrickson, R.J. La Haye

d)* lWepP1 3 "Comparison of Experimental Diagnostic Signals with Numerical Predictions," K. Comer, A.D. Turnbull

e) lWepP2 33 "On Attempts to Explain Nonlocal Electron Heat Transport" M.W. Kissick, J.D. Callen, Z. Chang, E.D. Fredrickson, C.C. Hegna, J.E. Kinsey, D.P. Schissel

[16] Oral talk at Workshop on Control of MHD Modes in Tokamaks With Non-Axisymmetric Coils, Columbia Univ., 24 November 1998:

C.C. Hegna, "Use of External Perturbations to Investigate Neoclassical Tearing Modes,"

[17] Poster Presentation at International Plasma Simulation Conference, Santa Barbara, CA, 10-12 February 1998:

"Nonlinear Tearing Mode Stability Using 'Almost Ideal' Constraint," C. Ren, T.H. Jensen and J.D. Callen

[18]* Summary talk on "Transient Transport," J.D. Callen at TTF Workshop, Atlanta, GA, 18-21 March 1998.

[19] Oral talk at MHD Working Group Meeting, Atlanta, GA, 22 March 1998:

J.D. Callen, "Growth of an Ideal MHD Mode Driven Slowly Through its Instability Threshold: Application to Disruption Precursors"

[20] Posters at Sherwood Fusion Theory Conference, Atlanta, GA, 23-25 March 1998:

a) 1C30 "Seed Magnetic Island Formation due to Geometrically Coupled Magnetic Perturbations," C.C. Hegna, J.D. Callen

b) 1D11 "Growth of an Ideal MHD Mode Driven Slowly Through its Instability Threshold: Application to Disruptions," J.D. Callen, C.C. Hegna, E.J. Strait, A.D. Turnbull

c) 1D16 "Magnetic Island Structure with Sheared Flow and Viscosity," C. Ren, M.S. Chu, J.D. Callen

d)* 2C12 "The Effect of Shear Flow on Neoclassical Tearing Modes," S.E. Kruger, C.C. Hegna, J.D. Callen

e)* 3C21 "Two Tokamak Applications of NIMROD: Ballooning Modes and Secondary Island Generation by Mode Coupling," T.A. Gianakon, C.R. Sovinec, A.H. Glasser, M.S. Chu

[21] Talks At Nonlinear MHD and Extended MHD Workshop, Atlanta, GA, 25-26 March 1998:

a)* T.A. Gianakon, "Simulations on the Feedback Stabilization of Neoclassical Tearing Modes with Neofar"

b) C. Ren, "Nonlinear Tearing Mode Studies Using 'Almost Ideal' Constraint"

Seminars and Other Scientific or Programmatic Presentations:

[22] C. Ren, "Study of Tearing Modes on DIII-D by ECE Data Analysis," MHD Group Meeting, General Atomics, 29 October 1997.

[23]* J.D. Callen, "Evidence and Concepts for Nonlocal Transport," PSFC Seminar, M.I.T., Cambridge, MA, 4 December 1997.

[24] J.D. Callen, "What is Worth Calculating for Tearing Modes in DIII-D," at Resistive MHD Interest Group Meeting, General Atomics, San Diego, CA, 14 January 1998.

[25] J.D. Callen, "Are Disruptions Driven Ideal MHD Instabilities?" MHD Group Meeting, General Atomics, San Diego, CA, 14 January 1998.

[26] C. Ren, "A Study Of Tearing Modes Using ECE From Tokamak Plasmas," Applied Physics Department, Columbia University, NY, 15 June 1998.

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