

Carlos Paz-Soldan

Scientist, General Atomics
DIII-D Program

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Education

Ph.D., Physics University of Wisconsin-Madison, 2007–2012
Awarded the Marshall N. Rosenbluth [Outstanding Doctoral Thesis Award](#) for the [Thesis: Stabilization of the Resistive Wall Mode and Error Field Modification by a Rotating Conducting Wall](#)

B.Sc.E., Engineering Physics Queen's University at Kingston, 2003–2007

Research Experience

Staff Scientist and Post-doctoral Fellow 2012–present
[DIII-D National Fusion Facility](#) General Atomics, CA

Research on Non-Axisymmetric Fields in Tokamaks

My research focuses on the interaction of non-axisymmetric (3D) fields in tokamaks and how they can be controlled to mitigate the effects of unwanted ‘error fields’ and suppress edge-localized modes (ELMs), both of which share a common physical basis. I have conducted experiments to validate theoretical predictions of what applied 3D spectrum is most and least effective to control against these effects, and [made new measurements](#) of the plasma’s response to 3D fields as part of these studies. *Selected Publications:*

C. Paz-Soldan, N.C. Logan, S.R. Haskey, R. Nazikian, E.J. Strait, X. Chen, N.M. Ferraro, J.D. King, B.C. Lyons and J.-K. Park, *Equilibrium drives of the low and high field side $n = 2$ plasma response and impact on global confinement*, [Nucl. Fusion](#) **56**, 056001 (2016)

C. Paz-Soldan, N.C. Logan, M.J. Lanctot, J.M. Hanson, J.D. King, R.J. La Haye, R. Nazikian, J.-K. Park and E.J. Strait, *Decoupled recovery of energy and momentum with correction of $n=2$ error fields*, [Nucl. Fusion](#) **54**, 083012 (2015)

R. Nazikian, **C. Paz-Soldan**, J. D. Callen, J. S. deGrassie, D. Eldon, T. E. Evans, N. M. Ferraro, B. A. Grierson, R. J. Groebner, S. R. Haskey, C. C. Hegna, J. D. King, N. C. Logan, G. R. McKee, R. A. Moyer, M. Okabayashi, D. M. Orlov, T. H. Osborne, J-K. Park, T. L. Rhodes, M. W. Shafer, P. B. Snyder, W. M. Solomon, E. J. Strait, and M. R. Wade, *Pedestal Bifurcation and Resonant Field Penetration at the Threshold of Edge-Localized Mode Suppression in the DIII-D Tokamak*, [Phys. Rev. Lett.](#) **114**, 105002 (2015)

C. Paz-Soldan, R. Nazikian, S. R. Haskey, N. C. Logan, E. J. Strait, N. M. Ferraro, J. M. Hanson, J. D. King, M. J. Lanctot, R. A. Moyer, M. Okabayashi, J-K. Park, M. W. Shafer, and B. J. Tobias, *Observation of a Multimode Plasma Response and its Relationship to Density Pumpout and Edge-Localized Mode Suppression*, [Phys. Rev. Lett.](#) **114**, 105001 (2015)

C. Paz-Soldan, M. J. Lanctot, N. C. Logan, D. Shiraki, R. J. Buttery, J. M. Hanson, R. J. La Haye, J-K. Park, W. Solomon, E. J. Strait, *The importance of matched poloidal spectra to error field correction in DIII-D*, [Phys. Plasmas](#) **21**, 072503 (2014)

C. Paz-Soldan, R.J. Buttery, A.M. Garofalo, J.M. Hanson, R.J. La Haye, M.J. Lanctot, J-K. Park, W. Solomon, E.J. Strait, *The spectral basis of optimal error field correction on DIII-D*, [Nucl. Fusion](#) **54**, 073013 (2014)

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Research on Runaway Electrons in Tokamaks

My research in runaway electrons has focused on measurements in the ‘quiescent’ regime to elucidate the underlying mechanisms governing the growth and decay of runaway electrons in tokamaks. My early work demonstrated an elevated electric field criteria for runaway growth which helped promote significant theoretical efforts to understand these and similar results. Measurements have since been enhanced by the [Gamma Ray Imaging](#) system which measures the dynamics of the runaway electrons in unprecedented detail and allows detailed comparison with theory. Most recently, I have been exploring the [interaction of kinetic instabilities](#) with the runaway beam, both to explain previous measurements and improve control in the future. *Selected Publications:*

C. Paz-Soldan P. Aleynikov, N. W. Eidietis, A. Lvovskiy, D. C. Pace, D. P. Brennan, E. M. Hollmann, C. Liu, R. A. Moyer, and D. Shiraki, *Resolving Runaway Electron Distributions in Space, Time, and Energy*, [Phys. Plasmas](#) **25**, 056105 (2018)

D. Spong, W. Heidbrink, **C. Paz-Soldan**, X.D. Du, K.E. Thome, M.A. Van Zeeland, C. Collins, A. Lvovskiy, R.A. Moyer, M.E. Austin, D.P. Brennan, C. Liu, E.F. Jaeger, and C. Lau *First Direct Observation of Runaway-Electron-Driven Whistler Waves in Tokamaks*, [Phys. Rev. Lett.](#) **120**, 155002 (2018)

C. Paz-Soldan, C.M. Cooper, P. Aleynikov, D.C. Pace, N.W. Eidietis, D.P. Brennan, R.S. Granetz, E.M. Hollmann, C. Liu, A. Lvovskiy, R.A. Moyer, and D. Shiraki, *Spatiotemporal Evolution of Runaway Electron Momentum Distributions in Tokamaks*, [Phys. Rev. Lett.](#) **118**, 255002 (2017)

R. S. Granetz, B. Esposito, J. H. Kim, R. Koslowski, M. Lehnen, J. R. Martin-Solis, **C. Paz-Soldan**, T. Rhee, J. C. Wesley, L. Zeng and the ITPA MHD Group *An ITPA joint experiment to study runaway electron generation and suppression*, [Phys. Plasmas](#) **21**, 072506 (2014)

C. Paz-Soldan, N.W. Eidietis, R. Granetz, E.M. Hollmann, R.A. Moyer, J.C. Wesley, J. Zhang, M.E. Austin, N. A. Crocker, A. Wingen, Y. Zhu, *Growth and decay of runaway electrons above the critical electric field under quiescent conditions*, [Phys. Plasmas](#) **21**, 022514 (2014)

Doctoral Research on MHD Stability

My doctoral research was in the [Plasma Physics Group](#) of the University of Wisconsin-Madison under Professor Cary Forest. I designed and constructed a high-speed rotating machine (50 kg at 300 km/h) to study the interaction of moving conductors with plasma instabilities. I worked with magnetic diagnostics, optical diagnostics, and in-situ probes, maintained the vacuum, mechanical, electrical, and software systems of our lab, and mentored several undergraduate students. My research demonstrated the stabilizing effect of the rotating conducting wall, uncovered interactions with static laboratory-frame magnetic fields, and documented non-axisymmetric states of the laboratory plasma. For this work I received the Awarded the Marshall N. Rosenbluth [Outstanding Doctoral Thesis Award](#). *Selected Publications:*

C. Paz-Soldan, M.I. Brookhart, C.C. Hegna, C.B. Forest, *Asymmetric error field interaction with a rotating conducting wall*, [Phys. Plasmas](#) **19**, 072511 (2012)

C. Paz-Soldan, M.I. Brookhart, A.T. Eckhart, D.A. Hannum, C.C. Hegna, J.S. Sarff, C.B. Forest, *Stabilization of the Resistive Wall Mode by a Rotating Conducting Wall*, [Phys. Rev. Lett.](#) **107**, 245001 (2011)

C. Paz-Soldan, M.I. Brookhart, D.A. Hannum, A.J. Clinch, C.B. Forest, *Two-Dimensional Axisymmetric and Three-Dimensional Helical Equilibrium in the Line-Tied Screw Pinch*, [Phys. Plasmas](#) **18**, 052114 (2011)

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Undergraduate Research Internships

I was fortunate to participate in three full-time summer research internships as an undergraduate. In the first at the [Sudbury Neutrino Observatory](#) (2004) I wrote computer programs to perform height pulse analysis and discrimination. For the second (2006) I worked with [Professor Taillefer's Superconductivity Group](#) to design and implement a miniature mK-range thermal and electrical conductivity apparatus. My final internship (2007) was at the [University of Saskatchewan Plasma Physics Laboratory](#) where I designed and implemented a soft X-ray diagnostic for the STOR-M Tokamak facility. *Selected Publications:*

C. Xiao, T. Niu, J. E. Morelli, **C. Paz-Soldan**, M. Dreval, S. Elgriw, A. Pant, D. Rohraff, D. Trembach, A. Hirose, *Design and Initial Operation of Multichord Soft X-Ray Detection Arrays on the STOR-M Tokamak*, [Rev. Sci. Instrum.](#) **79**, 10E926 (2008)

Invited Conference Talks

American Physical Society–Division of Plasma Physics Meeting	Milwaukee, WI 2017
International Atomic Energy Agency Fusion Energy Conference	Kyoto, Japan 2016
American Physical Society–Division of Plasma Physics Meeting	Denver, CO 2013
American Physical Society–Division of Plasma Physics Meeting	Salt Lake City, UT 2011

Invited Seminars / Colloquia

University of Wisconsin–Madison, Special Seminar	Apr 2018
Massachusetts Institute of Technology, Plasma Science and Fusion Center Seminar	Dec 2016
University of Wisconsin–Madison, Seminar in Plasma Physics	Sept 2015
Princeton Plasma Physics Laboratory, Seminar	July 2015
Massachusetts Institute of Technology, Plasma Science and Fusion Center Seminar	Nov 2014
University of California–Los Angeles, Plasma Physics Colloquium	Mar 2014
University of California–Irvine, Plasma Physics Colloquium	Feb 2013
University of Wisconsin–Madison, Seminar in Plasma Physics	Mar 2012

Selected Co-Author Publications

Papers on the above discussed research areas and beyond, see [Google Scholar](#) for a complete list.

R. A. Moyer, **C. Paz-Soldan**, R. Nazikian, D. M. Orlov, N. M. Ferraro, B. A. Grierson, M. Klocker, B. C. Lyons, G. R. McKee, T. H. Osborne, T. L. Rhodes, O. Meneghini, S. Smith, T. E. Evans, M. E. Fenstermacher, R. J. Groebner, J. M. Hanson, R. J. La Haye, T. C. Luce, S. Mordijck, W. M. Solomon, F. Turco, Z. Yan, and L. Zeng. *Validation of the model for ELM suppression with 3D magnetic fields using low torque ITER baseline scenario discharges in DIII-D* [Phys. Plasmas](#), **24** 102501 (2017)

B. C. Lyons, N M Ferraro, **C. Paz-Soldan**, R Nazikian, and A. Wingen. *Effect of rotation zero-crossing on single-fluid plasma response to three-dimensional magnetic perturbations*. [Plasma Phys. Contr. Fusion](#), **59** 044001 (2017)

C. M. Cooper, D. C. Pace, **C. Paz-Soldan**, N. Commaux, N. W. Eidietis, E. M. Hollmann, and D. Shiraki, *Applying the new gamma ray imager diagnostic to measurements of runaway electron Bremsstrahlung radiation in the DIII-D Tokamak*, [Rev. Sci. Instrum.](#) **87**, 11E602 (2016)

M.J. Lanctot, K.E.J. Olofsson, M. Capella, D.A. Humphreys, N. Eidietis, J.M. Hanson, **C. Paz-Soldan**, E.J. Strait, and M.L. Walker, *Error field optimization in DIII-D using extremum seeking control* [Nucl. Fusion](#), **56** 076003 (2016)

Selectd Co-Author Publications (Continued)

R. S. Wilcox, M. W. Shafer, N. M. Ferraro, G. R. McKee, L. Zeng, T. L. Rhodes, J. M. Canik, **C. Paz-Soldan**, R. Nazikian, and E. A. Unterberg, *Evidence of Toroidally Localized Turbulence with Applied 3D Fields in the DIII-D Tokamak*, *Phys. Rev. Lett.* **117**, 135001 (2016)

N.C. Logan, **C. Paz-Soldan**, J.-K. Park, R. Nazikian, *Identification of multi-modal plasma responses to applied magnetic perturbations using the plasma reluctance*, *Phys. Plasmas*, **23** 056110 (2016)

D.M. Orlov, R.A. Moyer, T.E. Evans, **C. Paz-Soldan**, N.M. Ferraro, R. Nazikian, J.S. deGrassie, B.A. Grierson, D. Eldon, M.E. Fenstermacher, J.D. King, N.C. Logan, M.J. Lanctot, R. Maingi, P.B. Snyder, E.J. Strait and A. Wingen, *Suppression of type-I ELMs with reduced RMP coil set on DIII-D* *Nucl. Fusion*, **56** 036020 (2016)

N.C. Logan, J.-K. Park, **C. Paz-Soldan**, M.J. Lanctot, S.P. Smith and K.H. Burrell, *Dependence of neoclassical toroidal viscosity on the poloidal spectrum of applied nonaxisymmetric fields*, *Nucl. Fusion*, **56** 036008 (2016)

R.J. Hawryluk, N.W. Eidietis, B.A. Grierson, A.W. Hyatt, E. Kolemen, N.C. Logan, R. Nazikian, **C. Paz-Soldan**, W.M. Solomon and S. Wolfe, *Control of plasma stored energy for burn control using DIII-D in-vessel coils*, *Nucl. Fusion*, **55** 053001 (2015)

R. J. La Haye, **C. Paz-Soldan**, E. J. Strait, *Lack of dependence on resonant error field of locked mode island size in ohmic plasmas in DIII-D*, *Nucl. Fusion*, **55** 023011 (2015)

D. Shiraki, **C. Paz-Soldan**, J. M. Hanson, R. J. La Haye, N. C. Logan, K. E. J. Olofsson, E. J. Strait, R. M. Sweeney, F. A. Volpe, *Measurements of the toroidal torque balance of error field penetration locked modes*, *Plasma Phys. Control. Fusion* **57** 025016 (2015)

S. R. Haskey, M. J. Lanctot, Y. Q. Liu, **C. Paz-Soldan**, J. D. King, B. D. Blackwell and O Schmitz, *Effects of resistivity and rotation on the linear plasma response to non-axisymmetric magnetic perturbations on DIII-D*, *Plasma Phys. Control. Fusion* **57** 025015 (2015)

J. D. King, E. J. Strait, R. L. Boivin, D. Taussig, M. G. Watkins, J. M. Hanson, N. C. Logan, **C. Paz-Soldan**, D. C. Pace, D. Shiraki, M. J. Lanctot, R. J. La Haye, L. L. Lao, D. J. Battaglia, A. C. Sontag, S. R. Haskey and J. G. Bak. *An upgrade of the magnetic diagnostic system of the DIII-D tokamak for non-axisymmetric measurements*, *Rev. Sci. Instrum.* **85**, 083503 (2014)

P. Piovesan, J. M. Hanson, P. Martin, G. A. Navratil, F. Turco, J. Bialek, N. M. Ferraro, R. J. La Haye, M. J. Lanctot, M. Okabayashi, **C. Paz-Soldan**, E. J. Strait, A. D. Turnbull, P. Zanca, M. Baruzzo, T. Bolzonella, A. W. Hyatt, G. L. Jackson, L. Marrelli, L. Piron, and D. Shiraki, *Tokamak Operation with Safety Factor $q_{95} < 2$ via Control of MHD Stability*, *Phys. Rev. Lett.*, **113** 045003 (2014)

J. M. Hanson, J. M. Bialek, M. Baruzzo, T. Bolzonella, A. W. Hyatt, G. L. Jackson, J. King, R. J. La Haye, M. J. Lanctot, L. Marrelli, P. Martin, G. A. Navratil, M. Okabayashi, K. E. J. Olofsson, **C. Paz-Soldan**, P. Piovesan, C. Piron, L. Piron, D. Shiraki, E. J. Strait, D. Terranova, F. Turco, A. D. Turnbull and P. Zanca. *Feedback-assisted extension of the tokamak operating space to low safety factor*, *Phys. Plasmas* **21**, 072107 (2014)

I.V. Khalzov, B.P. Brown, E.J. Kaplan, N. Katz, **C. Paz-Soldan**, K. Rahbarnia, E.J. Spence, C.B. Forest, *Resistive and ferritic-wall plasma dynamos in a sphere*, *Phys. Plasmas* **19**, 104501 (2012)