Chang Liu

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Work Experience

Staff Research Physicist at Princeton Plasma Physics Laboratory
March 1st 2019 - Present
100 Stellarator Rd, Princeton NJ 08540

Associate Research Physicist at Princeton Plasma Physics Laboratory
March 1st 2017 - March 1st 2019
100 Stellarator Rd, Princeton NJ 08540

Education

PhD 2011-2017 February
Astrophysical Sciences, Program in Plasma Physics, Princeton University, Princeton, USA

Bachelor of Science 2007-2011
Physics, Peking University, Beijing, China

Research Experience

2019-Present **Simulation of MHD and Alfvén instabilities driven by energetic ions and runaway electrons**
Supervisor: Amitava Bhattacharjee, Steve Jardin

- Develop a new kinetic module in M3D-C1 MHD code to simulate dynamics of energetic particles in tokamak and coupling with MHD.
- Optimize the particle pushing calculation and finite element calculation in M3D-C1 using GPUs.
- Use the developed code to study nonlinear behavior of Alfvén modes and fishbone modes driven by fast /thermal ions and runaway electrons in tokamaks
- Develop a fluid-based runaway electron module in M3D-C1 and conduct simulations of MHD instabilities in post-disruption plasmas with strong RE current.

2017-2019 **Kinetic instabilities associated with highly energetic electrons**
Supervisor: Amitava Bhattacharjee, Steve Jardin, Guo-yong Fu

- Studied magnetosonic-whistler instabilities excited by runaway electrons in tokamak disruptions, and radial diffusion caused by eigenmodes.
- Studied the effects of kinetic instabilities of runaway electrons on the avalanche growth rate and non-thermal radiation like ECE.
- Developed a new gyrokinetic theory for relativistic runaway electrons based on the Lie-perturbation method including higher-order corrections to magnetic moments.

2013-2017 **Study of runaway electrons in tokamak** PhD Thesis project
Advisors: Dylan Brennan, Amitava Bhattacharjee

- Developed a simulation code, QUADRE, to study the excitation of kinetic instabilities by the runaway electron population generated in tokamak experiments and the diffusion of resonance electrons using quasilinear approximation.
- Developed an ECE synthetic diagnostic tool for the runaway electron distribution using reciprocal method, to benchmark the kinetic instability simulation with experimental observations.
- Applied the backward stochastic differential equation (BSDE) to study the runaway probability and the expected loss time for runaway electrons.
- Studied the Cherenkov radiation of runaway electrons in magnetized plasmas, and calculated a correction to the logΛ term in the collision operator due to magnetization.

2012-2013 **Plasma wave dispersion including fluid and kinetic nonlinear effects**
Advisor: Ilya Dodin

- Found a new method based on variational principle to study the frequency shift of plasma waves due to wave-particle interaction including both fluid and kinetic effects consistently.

2012-2013 **Heat flux driven magnetic reconnection in HEDP including Nernst effect and heat flux viscosity**
Advisor: Will Fox, Amitava Bhattacharjee

- Studied the magnetic reconnection mechanism driven in high energy density plasma with strong heat flux using Chapman-Enskog method.

2011-2012 **Study on PFRC (Princeton Field-Reversed Configuration) project**
Advisor: Samuel Cohen

2009-2010 **Gyrokinetic Fokker-Planck collision operator in Lorentz model**
Advisor: Hong Qin, Xiaogang Wang

Teaching experience

2016 Teaching Assistant at AST554 Irreversible Processes in Plasmas
School: Princeton University
Lecturer: Greg Hammett

2014 Teaching Assistant at AST553 Plasma Waves and Instabilities
School: Princeton University
Lecturer: Ilya Dodin

2013 Teaching Assistant at AST551 General Plasma Physics I
(Including one lecture given in charge of Prof. Fisch)
School: Princeton University
Lecturer: Nathaniel Fisch

Invited Talks

Invited talk at OpenACC and Hackathons Summit 2022
Invited talk at the 30th International Toki Conference (2021)
Invited talk at the 58th and 63rd Annual Meeting of the APS Division of Plasma Physics (2016, 2021)
Invited talk at the 5th Asia Pacific Conference on Plasma Physics (AAPPS-DPP) (2021)
Invited talks at Theory and Simulation of Disruption Workshop 2016-2021

Invited talk at Runaway Electron Meeting (REM) 2016 and 2018
Invited talk at 2016 International Sherwood Fusion Theory Conference

Publications (refereed and published)

J. Yang, M. Podestà, E.D. Fredrickson, C. Liu, J.W. Berkery, and F.M. Poli, "*The role of fast ions in spontaneous neoclassical tearing mode instabilities in NSTX*," Plasma Phys. Control. Fusion **65**(6), 064004 (**2023**).
A. Lvovskiy, C. Paz-Soldan, N.W. Eidietis, A.D. Molin, G.H. DeGrandchamp, E.M. Hollmann, J.B. Lestz, C. Liu, M. Nocente, D. Shiraki, and X.D. Du, "*Parametric study of Alfvénic instabilities driven by runaway electrons during the current quench in DIII-D*," Nucl. Fusion **63**(4), 046011 (**2023**).
S.-J. Liu, F. Wang, C. Liu, D. Hu, K.-B. Wu, J. Liu, and Z.-X. Wang, "Calculation of collisionless pitch-angle scattering of runaway electrons with synchrotron radiation via high-order guiding-centre equation," Journal of Plasma Physics **88**(5), 905880505 (**2022**).
C. Liu, S.C. Jardin, J. Bao, N. Gorelenkov, D.P. Brennan, J. Yang, and M. Podesta, "*Thermal ion kinetic effects and Landau damping in fishbone modes*", J. Plasma Phys. **88**, 905880610 (**2022**).
D. Hu, C. Liu, and the J. Team, "*Hot-tail electrons' impact on assimilation and injection penetration of D2 shattered pellet injections*," Nucl. Fusion **62**(9), 096002 (**2022**).
G. Brochard, J. Bao, C. Liu, N. Gorelenkov, G. Choi, G. Dong, P. Liu, J. Mc.Clenaghan, J.H. Nicolau, F. Wang, W.H. Wang, X. Wei, W.L. Zhang, W. Heidbrink, J.P. Graves, Z. Lin, and H. Lütjens, "Verification and validation of linear gyrokinetic and kinetic-MHD simulations for internal kink instability in DIII-D tokamak," Nucl. Fusion **62**(3), 036021 (**2022**).
C. Liu, S.C. Jardin, H. Qin, J. Xiao, N.M. Ferraro, and J. Breslau, "*Hybrid simulation of energetic particles interacting with magnetohydrodynamics using a slow manifold algorithm and GPU acceleration*",Comput. Phys. Commun. **275**, 108313 (2022). (**2021**).
F. Zonta, R. Iorio, J.W. Burby, C. Liu, and E. Hirvijoki, "*Dispersion relation for gauge-free electromagnetic drift kinetics*", Physics of Plasmas **28**, 092504 (**2021**).
C. Paz-Soldan, C. Reux, K. Aleynikova, P. Aleynikov, V. Bandaru, M. Beidler, N. Eidietis, Y.Q. Liu, C. Liu, A. Lvovskiy, S. Silburn, L. Bardoczi, L. Baylor, I. Bykov, D. Carnevale, D.D.-C. Negrete, X. Du, O. Ficker, S. Gerasimov, M. Hoelzl, E. Hollmann, S. Jachmich, S. Jardin, E. Joffrin, C. Lasnier, M. Lehnen, E. Macusova, A. Manzanares, G. Papp, G. Pautasso, Z. Popovic, F. Rimini, D. Shiraki, C. Sommariva, D. Spong, S. Sridhar, G. Szepesi, C. Zhao, the D.-D. Team, and J.E.T. Contributors, "*A novel path to runaway electron mitigation via deuterium injection and current-driven MHD instability*", Nucl. Fusion **61**, 116058 (**2021**).
C. Liu, C. Zhao, S.C. Jardin, N. Ferraro, C. Paz-Soldan, Y. Liu, and B.C. Lyons, "*Self-consistent simulation of resistive kink instabilities with runaway electrons*", Plasma Phys. Control. Fusion **63**, 125031 (**2021**).
C. Liu, D.P. Brennan, A. Lvovskiy, C. Paz-Soldan, E.D. Fredrickson, and A. Bhattacharjee, "*Compressional Alfvén eigenmodes excited by runaway electrons*", Nucl. Fusion **61**, 036011 (**2021**).
C. Liu, C. Zhao, S.C. Jardin, A. Bhattacharjee, D.P. Brennan, and N.M. Ferraro, "*Structure and overstability of resistive modes with runaway electrons*", Phys. Plasmas **27**, 092507 (**2020**).
C. Zhao, C. Liu, S.C. Jardin, and N.M. Ferraro, "*Simulation of MHD instabilities with fluid runaway electron model in M3D-C1*", Nucl. Fusion **60**, 126017 (**2020**).

Y. Liu, T. Zhou, Y. Hu, C. Liu, R. Zhou, T. Zhang, H. Zhao, Z. Zhu, X. Liu, and B. Ling, *"Intense intermittent radiation at the plasma frequency on EAST"*, Nucl. Fusion **59**, 106024 (**2019**).

C. Liu, H. Qin, E. Hirvijoki, Y. Wang, and J. Liu, *"Conservative magnetic moment of runaway electrons and collisionless pitch-angle scattering"*, Nucl. Fusion **58**, 106018 (**2018**).

C. Liu, L. Shi, E. Hirvijoki, D.P. Brennan, A. Bhattacharjee, C. Paz-Soldan, and M.E. Austin, "*The effects of kinetic instabilities on the electron cyclotron emission from runaway electrons*", Nucl. Fusion **58**, 096030 (**2018**).

C. Liu, E. Hirvijoki, G.-Y. Fu, D.P. Brennan, A. Bhattacharjee, and C. Paz-Soldan, "*Role of kinetic instability in runaway electron avalanche and elevated critical electric fields*", Phys. Rev. Lett. **120**, 265001 (**2018**).

E. Hirvijoki, C. Liu, G. Zhang, D. del-Castillo-Negrete, and D.P. Brennan, "*A fluid-kinetic framework for self-consistent runaway-electron simulations*", Physics of Plasmas **25**, 062507 (**2018**).

D.A. Spong, W.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, 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**).

C. Liu, W. Fox, A. Bhattacharjee, A.G.R. Thomas, and A.S. Joglekar, "*Momentum transport and nonlocality in heat-flux-driven magnetic reconnection in high-energy-density plasmas*", Phys. Rev. E **96**, 043203 (**2017**).

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**).

C. Liu, D.P. Brennan, A.H. Boozer, and A. Bhattacharjee, "*Adjoint method and runaway electron avalanche* ", Plasma Phys. Control. Fusion **59**, 24003 (**2017**).

Chang Liu, Dylan P. Brennan, Allen H. Boozer, and Amitava Bhattacharjee, "*Adjoint Fokker-Planck equation and runaway electron dynamics*", Phys. Plasmas **23**, 010702 (**2016**).

Chang Liu and Ilya Dodin, "*Nonlinear frequency shift of electrostatic waves in general collisionless plasma: unifying theory of fluid and kinetic nonlinearities*", Phys. Plasmas **22**, 082117 (**2015**).

Chang Liu, Will Fox, and Amitava Bhattacharjee, "*Heat flux viscosity in collisional magnetized plasmas*", Physics of Plasmas **22**, 053302 (**2015**).

Chang Liu, Hong Qin, Chenhao Ma, and Xiongjie Yu, "*A gyrokinetic collision operator for magnetized Lorentz plasmas"*, Phys. Plasmas **18**, 032502 (**2011**).

Publications (not published)

C. Liu, A. Lvovskiy, C. Paz-Soldan, S.C. Jardin, and A. Bhattacharjee, "*Self-consistent simulation of compressional Alfvén eigenmodes excited by runaway electrons*," submitted to Phys. Rev. Lett., arXiv:2303.03622(**2023**).

G. Brochard, C. Liu, X. Wei, W. Heidbrink, Z. Lin, N. Gorelenkov, C. Chrystal, X. Du, J. Bao, A.R. Polevoi, M. Schneider, S.H. Kim, S.D. Pinches, P. Liu, J.H. Nicolau, and H. Lütjens, "*Saturation of fishbone instability by self-generated zonal flows in tokamak plasmas*," submitted to Phys. Rev. Lett., arXiv:2301.01792 (**2023**).