Curriculum Vitae of Prof. C. Z. Cheng

PERSENT POSITIONS:

Chair Professor, College of Science, National Cheng Kung University (from August, 2006)
Director, Plasma and Space Science Center, National Cheng Kung University (from August, 2006)
Director, Satellite Geoinformatics Research Center, National Cheng Kung University (from March, 2007)

HONORS AND AWARDS:

1. Award For Excellence In Plasma Physics Research (2004, American Physical Society)
   Citation: ”For the theoretical discovery and experimental identification of Torodicity Induced Alfven Eigenmodes”
2. Distinguished Research Fellow (1999, Princeton Plasma Physics Laboratory)
   Citation: ”For outstanding contributions to the theory of the interaction of high energy particles and magnetohydrodynamic modes, such as the Fishbone and the Toroidal Alfven Eigenmode, and for important contributions to Magnetospheric physics”
3. American Physical Society Fellow (1991)
   Citation: ”For original work in the investigation of magnetohydrodynamic instabilities important in fusion plasmas, and the modification of these instabilities by high energy particles”
4. The Physical Society of the Republic of China (PSROC) Fellow (2009)
   Citation: ”For original work in plasma physics and, in particular, the prediction of the existence of Toroidicity-Induced Alfven Eigenmode (TAE)”

MAJOR RESEARCH CONTRIBUTIONS:

(1) **Theoretical discovery of Toroidicity-Induced Alfvén Eigenmodes in tokamaks:** Dr. Cheng discovered the theory of Toroidicity-Induced Alfvén Eigenmodes (TAEs) in toroidal magnetic confinement fusion devices in 1984-85 and predicted that TAEs can be destabilized by energetic particles and can cause serious loss of energetic particles. TAE instabilities by energetic particles were later confirmed in Princeton's TFTR tokamak experiments in 1990 and subsequently observed in all major toroidal fusion confinement devices. In fusion reactors 3.5 MeV α-particles (product of Deuterium-Tritium fusion reaction) can be expelled from the reactor plasma by TAEs, which can degrade the reactor operation efficiency, and the lost α-particles can even damage the reactor first wall. **Dr. Cheng pioneered the field of energetic particle physics** and has continued to lead this field and work with experimentalists. In 2004 he received the American Physical Society "**Award For Excellence In Plasma Physics Research**" with the citation "For the theoretical discovery and experimental identification of Torodicity-Induced Alfvén Eigenmodes." In 1996 he received a "**Distinguished Research Fellow Award**" from Princeton Plasma Physics Laboratory recognizing his contributions to energetic particle physics and space physics.

C. Z. Cheng, L. Chen, and M. S. Chance, *High-n Ideal and Resistive Shear Alfvén Waves in Tokamaks,* Annal Physics, 161, 21-47 (1985)

C. Z. Cheng and M. S. Chance, *Low-n Shear Alfvén Spectra in Axisymmetric Toroidal Plasmas*, Physics of Fluids, 29, 3695-3701 (1986)

C. Z. Cheng, *Alpha Particle Destabilization of the Toroidicity-Induced Alfvén Eigenmodes,* Physics of Fluids B, 3, 2463-2471 (1991)

(2) **Invention of splitting scheme for solving Vlasov-Maxwell equations:** Dr. Cheng **invented** an efficient numerical method (splitting scheme) for solving Vlasov-Maxwell equations (1976), which are the fundamental equations describing plasma dynamics. Since the Cheng & Knorr (1976) paper was published, the splitting scheme has been extensively employed in many papers. He also developed NOVA-K code (1992), which is the international standard for calculating TAE stability in tokamaks. In 1995 he also developed the MAG-3D code, which is used for modeling 3D magnetosphere with thin current sheet in the near-Earth plasma sheet region.

C. Z. Cheng and G. Knorr, *The Integration of Vlasov Equation in Configuration Space*, Journal of Computational Physics, 22, 330-351 (1976).

C. Z. Cheng and H. Okuda, *Formation of Convective Cells, Anomalous Diffusion and Strong Plasma turbalence Due to Drift Instabilities*, Physical Review Letters, 38, 708-711 (1977).

C. Z. Cheng, *Kinetic Extensions of Magnetohydrodynamics for Axisymmetric Toroidal Plasmas*, Physics Reports (A Review Sec. of Phys. Letters.), 211, 1-51 (1992)

C. Z. Cheng, *Three-dimensional Magnetospheric equilibrium with isotropic pressure,* Geophysical Research Letter, 22, 2401-2404 (1995)

(3) **Development of a new substorm onset mechanism:** Dr. Cheng developed a **new** kinetic ballooning instability (KBI) theory and **discovered new** observational evidence of KBI for understanding substorm onset mechanism (Cheng and Lui, Geophys. Res. Lett., 25, 4091, 1998 and Cheng, Space Science Review, 113, 207-270, 2004). He also developed a kinetic

Alfvén wave (KAW) theory to explain ULF waves observed in the magnetopause under various solar wind and interplanetary magnetic field conditions and effects of KAW on plasma transport across the magnetopause

C. Z. Cheng and A. T. Y. Lui, *Kinetic Ballooning Instability for Substorm Onset and Current Disruption Observed by AMPTE/CCE*, Geophysical Research Letter, 25, 4091-4094 (1998)

C. Z. Cheng, *Physics of Substorm Growth Phase, Onset, and Dipolarization*, Space Science Review, 113 (1), 207-270 (2004). (Review paper)

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(4) **Development of an impulsive magnetic reconnection theory for solar flare non-thermal emission and CME acceleration:** Dr. Cheng **developed a new impulsive magnetic reconnection theory** (2003)**,** which predicts that the impulsive non-thermal hard X-ray emission occurred during the solar flare rising phase is correlated in time with the acceleration phase of coronal mass ejections and an impulsive magnetic reconnection process. His theory also **predicted** the peak reconnection electric field to be about 1 kV/m for X-class flares, which was **later confirmed** by the magnetic reconnection electric field measurement inferred from the observed solar flare's two-ribbon expansion (e.g., Qiu et al., 2004 and many other papers thereafter).

C. Z. Cheng, Y. Ren, G. S. Choe and Y. J. Moon, *Flux Rope Acceleration and Enhanced Magnetic Reconnection*, Astrophysical Journal, 596, 1341-1346 (2003)

Jiong Qiu, Haimin Wang, **C. Z. Cheng**, and D. E. Gary, *Magnetic Reconnection and Mass Acceleration in Flare-CME Events*, Astrophysical Journal, 604 (2), 900-905 (2004).

SELECTED PUBLICATIONS

(1) Magnetic Confinement Fusion Physics

(a) Alfven Waves and Their Interaction with Energetic Particles:

C. Z. Cheng, L. Chen, and M. S. Chance, *High-n Ideal and Resistive Shear Alfven Waves in Tokamaks,* Annal of Physics, 161, 21-47 (1985).

C. Z. Cheng and M. S. Chance, *Low-n Shear Alfven Spectra in Axisymmetric Toroidal Plasmas*, Physics of Fluids, 29, 3695-3701 (1986).

C. Z. Cheng, *Energetic Particle Effects on Global Magnetohydrodynamic Modes*, Physics of Fluids B, 2, 1427-1434 (1990)

G. Y. Fu and **C. Z. Cheng,** *Theory of High-n Toroidicity-Induced Shear Alfvén Eigenmode in Tokamaks*, Physics of Fluids B, 2, 985-993 (1990)

C. Z. Cheng, *Alpha Particle Destabilization of the Toroidicity-Induced Alfven Eigenmodes*, Physics of Fluids B, 3, 2463-2471 (1991).

K. L. Wong, R. Durst, R. J. Fonck, S. F. Paul, D. R. Roberts, E. D. Fredrickson, R. Nazikian, H. K. Park, M. Bell, N. L. Bretz, R. Budney, **C. Z. Cheng**, S. Cohen, G. W. Hammett, F. C. Jobes, L. Johnson, D. Meade,S. S. Medley, D. Mueller, Y. Nagayama, D. K. Owens, S. Sabbagh, and E. J. Synakowski, *Investigation of Global Alfvén Instabilities in the Tokamak Fusion Test Reactor*, Physics of Fluids B, 4, 2122-2126 (1992)

G. Y. Fu and **C. Z. Cheng**, *Excitation of High-n Toroidicity-Induced Shear Alfvén Eigenmode by Energetic Particles and Fusion Alpha Particles in Tokamaks*, Physics of Fluids B, 4, 3722-3734 (1992)

D. J. Sigmar, C. T. Hsu, R. White, and **C. Z. Cheng,** *Alpha Particle Loss from Toroidicity Induced Alfvén Eigenmodes*, Physics of Fluids B, 4, 1506-1516 (1992)

C. T. Hsu, **C. Z. Cheng**, P. Helander, D. J. Sigmar, and R. B. White, *Convecting Bucket in Chirped Frequency Fluctuation*, Physical Review Letters, 72, 2503-2506 (1994).

D. J. Sigmar, **C. Z. Cheng**, G. J. Sadler, and S. J. Zweben, *Alpha Particles in Fusion Research*, Nuclear Fusion, 35, 1421-1428 (1995)

C. Z. Cheng, N. N. Gorelenkov, and C. T. Hsu, *Fast Particle Destabilization of High-n TAE Modes*, Nuclear Fusion, 35, 1639-1650 (1995).

G. Y. Fu, **C. Z. Cheng**, R. V. Budny, Z. Chang, D. S. Darrow, E. D.

Fredrickson, E. Mazzucatto, R. Nazikian and S. J. Zweben, *Stability Analysis of Toroidicity-Induced Alfvén Eigenmodes in TFTR Deuterium-Tritium Experiments*, Physical Review Letters, 75, 2336-2339 (1995).

G. Y. Fu, **C. Z. Cheng**, R. V. Budny, Z. Chang, D. S. Darrow, E. D. Fredrickson, E. Mazzucatto, R. Nazikian, K. L. Wong and S. J. Zweben, *Analysis of Alpha Particle-Driven Toroidal Alfvén Eigenmode in Tokamak Fusion Test Reactor Deuterium-Tritium Experiments*, Physics of Plasmas, 3, 4036-4045 (1996)

N. N. Gorelenkov, **C. Z. Cheng**, and G. Y. Fu, *Fast Particle Finite Orbit Width and Larmor Radius Effects on Low-n Toroidicity-induced Alfven Eigenmode Excitation*, Physics of Plasmas, 6, 2802-2807 (1999)

N. N. Gorelenkov, **C. Z. Cheng**, G. Y. Fu, S. Kaye, R. B. White and M. V. Gorelenkova, *Fast Particle Destabilization of Toroidicity Induced Alfven, Eigenmodes in National Spherical Torus Experiment*, Physics of Plasmas, 7, 1433-1436 (2000)

N. N. Gorelenkov, **C. Z. Cheng**, E. D. Fredrickson, E. Belova, D. Gates, S. Kaye, G. J. Kramer, R. Nazikian, R. White, *Compressional Alfven Eigenmode Instablility in NSTX*, Nuclear Fusion, 42, 977-985 (2002)

M. Takechi, M. Ishikawa, A. Fukuyama, **C. Z. Cheng**, K. Shinohara, T. Ozeki, Y. Kusama, S. Takeji, T. Fujita, T. Oikawa, T. Suzuki, N. Oyama, A. Morioka, N. N. Gorelenkov, G. J. Kramer, R. Nazikian, and the JT-60 team, *Alfven Eigenmodes in Reversed Shear Plasmas in JT-60U Negative-Ion-Based Neutral Beam Injection Discharges*, Physics of Plasmas, 12 (8), 082509 (7 pages) (2005)

M. Ishikawa, M. Takechi, K. Shinohawa, Y. Kusama, **C. Z. Cheng**, G. Matsunaga, Y. Todo, N. N. Gorelenkov, G. J. Kramer, R. Nazikian, A. Fukuyama, V. A. Krasilnikov, Y. Kashuck, T. Nishitani, A. Morioka, M. Sasao, M. Isobe, *Energetic ion transport by abrupt large-amplitude event induced by negative-ion-based neutral beam injection in the JT-60U*, Nuclear Fusion, 45, 12, 1474-1480 (2005)

(b) Particle Kinetic Effects on MHD Phenomena:

C. Z. Cheng, *Kinetic Theory of Collisionless Ballooning Modes*, Physics of Fluids, 25, 1020-1026 (1982).

C. Z. Cheng, *High-n Collisionless Ballooning Modes in Axisymmetric Toroidal Plasmas*, Nuclear Fusion, 22, 773-781 (1982).

C. Z. Cheng and Jay R. Johnson, *A Kinetic-Fluid Model*, Journal of

Geophysical Research, 104, 413-427 (1999)

C. Z. Cheng and N. N. Gorelenkov, *Trapped Electron Stabilization of Ballooning Modes in Low Aspect Ratio Toroidal Plasmas*, Physics of Plasmas, 11 (10), 4784-4795 (2004).

(c) Microinstabilities, Turbulence, and Plasma Transport:

C. Z. Cheng and H. Okuda, *Formation of Convective Cells, Anomalous Diffusion and Strong Plasma turbalence Due to Drift Instabilities*, Physical Review Letters, 38, 708-711 (1977).

C. Z. Cheng and H. Okuda, *Theory and Numerical Simulations on Collisionless Drift Instabilities in Three Dimensions*, Nuclear Fusion, 18, 587-607 (1978).

C. Z. Cheng and H. Okuda, *Numerical Simulation of Trapped Electron Instabilities in Toroidal Geometry*, Physical Review Letters, 41, 1116-1119 (1978).

L. Chen and **C. Z. Cheng**, *Theory of Drift-Wave Eigenmodes in Toroidal Plasmas*, Physics of Fluids, 23, 2242-2249 (1980).

C. Z. Cheng and L. Chen, *Ballooning Mode Theory of Trapped-Particle Instabilities in Tokamak*, Nuclear Fusion, 21, 403-408 (1981).

(2) Computational Physics

(a) Simulation of Vlasov-Maxwell Equations in Phase Space:

C. Z. Cheng and G. Knorr, *The Integration of Vlasov Equation in Configuration Space*, Journal of Computational Physics, 22, 330-351 (1976).

C. Z. Cheng, *The Integration of Vlasov Equation for a Magnetized Plasma*, Journal of Computational Physics, 24, 348-360 (1977).

(b) 3D Particle Simulation Code for Tokamak:

C. Z. Cheng and H. Okuda, *New Three-Dimensional Simulation Models for Cylindrical and Toridal Plasma*, Journal of Computational Physics, 25, 133-150 (1977).

(c) Non-Variational Global Stability Codes for Tokamak:

C. Z. Cheng and M. S. Chance, *NOVA: A Nonvariational Code for Solving MHD Stability of Axisymmetric Toroidal Plasmas*, Journal of Computational Physics, 71, 124-146 (1987).

C. Z. Cheng, *Kinetic Extensions of Magnetohydrodynamics for Axisymmetric Toroidal Plasmas*, Physics Reports (A Review Section of

Physics Letters), 211, 1-51 (1992).

N. Gorelenkov, **C. Z. Cheng** and W. M Tang, *HINST: A 2D Code For High-n TAE Stability*, Physics of Plasmas, 5, 3389-3397 (1998)

(d) Quasi-static Equilibrium Code for Magnetosphere:

C. Z. Cheng, *Magnetospheric Equilibrium with Anisotropic Pressure*, Journal of Geophysical Research, 97, 1497-1510 (1992)

C. Z. Cheng, *Three-Dimensional Magnetospheric Equilibrium with Isotropic Pressure*, Geophysical Research Letters, 22, 2401-2404 (1995).

S. Zaharia, **C. Z. Cheng** and K. Maezawa , *3D Force Balanced Magnetospheric Configurations*, Annals Geophysicae, 22 (1), 251-265 (2004)

S. Zaharia, J. Birn, **C. Z. Cheng**, *Toward a Global Magnetospheric Equilibrium*, Journal of Geophysical Research, 110, A9, A09228, 10.1029/2005JA011101 (2005)

(3) Magnetospheric Physics

(a) Pc Waves in Magnetosphere:

C. Z. Cheng and C. S. Lin, *Eigenmode Analysis of Compressional Waves in the Magnetosphere*, Geophysical Research Letters, 14, 884-887 (1987).

K. Takahashi, **C. Z. Cheng**, R. W. McEntire, T. A. Potemra, and L. M. Kistler, *Observation and Theory of Compressional Pc 5 Waves with Second-Harmonic Component*, Journal of Geophysical Research, 95, 977-989 (1990)

C. Z. Cheng and Q. Qian, *Theory of Ballooning and Mirror Instabilities for Anisotropic Pressure Plasmas in the Magnetosphere*, Journal of Geophysical Research, 99, 11193-11209 (1994).

Jay R. Johnson and **C. Z. Cheng**, *Can Ion Cyclotron Waves Propagate to the Ground?*, Geophysical Research Letters, 26, 671-674 (1999)

C. Z. Cheng, *MHD Field Line Resonances and Global Modes in Three-Dimensional Magnetic Fields*, Journal of Geophysical Research, 108, 1001, doi:10.1029/2002JA009470 (2003)

C. Z. Cheng and S. Zaharia, *Field Line Resonances in Quiet and Disturbed Time Three-Dimensional Magnetospheres*, Journal of Geophysical Research, 108, 1001, doi:10.1029/2002JA009471 (2003)

(b) Waves, Particle Heating and Transport at Magnetopause:

Jay R. Johnson and **C. Z. Cheng**, *Global Structure of Mirror Modes in the Magnetosheath*, Journal of Geophysical Research, 102, 7179-7189 (1997).

Jay R. Johnson and **C. Z. Cheng**, *Kinetic Alfven Waves and Plasma Transport at the Magnetopause*, Geophysical Research Letters, 24, 1423-1426 (1997)

Jay R. Johnson, **C. Z. Cheng**, and P. Song, *Signatures of Mode Conversion and Kinetic Alfven Waves at the Magnetopause*, Geophysical Research Letters, 28, 227-230 (2001)

Jay R. Johnson and **C. Z Cheng**, *Stochastic ion heating at the magnetopause due to kinetic Alfven waves*, Geophysical Research Letters, 28, 4421-4424 (2001)

(c) Substorms:

C. Z. Cheng and A. T. Y. Lui, *Kinetic Ballooning Instability for Substorm Onset and Current Disruption Observed by AMPTE/CCE*, Geophysical Research Letters, 25, 4091-4094 (1998).

S. Zaharia, **C. Z. Cheng** and Jay R. Johnson, *Particle Transport and Energization Associated with Disturbed Magnetospheric Events*, Journal of Geophysical Research, 105, 18741-18752 (2000).

Sorin Zaharia and **C. Z. Cheng**, *Near-Earth Thin Current Sheets and Birkeland Currents During Substorm Growth Phase*, Geophysical Research Letters, 30, 1883-1886 (2003)

C. Z. Cheng, *Physics of Substorm Growth Phase, Onset, and Dipolarization*, Space Science Review, 113 (1), 207-270 (2004).

C. Z. Cheng and S. Zaharia, *MHD Ballooning Instability in the Plasma Sheet*, Geophysical Research Letters, 31 (6), 6809, doi:10.1029/2003GL018823 (2004).

(4) Solar Physics

(a) Solar Magnetic Field:

C. Z. Cheng and G. S. Choe, *Current Sheets and Prominence Formation in the Solar Atmosphere*, Astrophysical Journal, 505, 376-389, (1998)

G. S. Choe and **C. Z. Cheng**, *A Model of Solar Flares and Their Homologous Behavior*, Astrophysical Journal, 541, 449-467 (2000)

G. S. Choe and **C. Z. Cheng**, *Energy of Force-Free Magnetic Fields in Relation to Coronal Mass Ejection*, Astrophysical Journal, 574, L179-L182 (2002)

(b) Solar Flare and Coronal Mass Ejection:

C. Z. Cheng, Y. Ren, G. S. Choe and Y. J. Moon, *Flux Rope Acceleration and Enhanced Magnetic Reconnection*, Astrophysical Journal, 596, 1341-1346 (2003)

Jiong Qiu, Haimin Wang, **C. Z. Cheng**, and D. E. Gary, *Magnetic Reconnection and Mass Acceleration in Flare-CME Events*, Astrophysical Journal, 604 (2), 900-905 (2004).

Ya-Hui Yang, **C. Z. Cheng**, Sam Krucker, and Min-Shiu Hsieh, *Estimation of reconnection electric field in the 2003 October 29 X10 flare*, Astrophysical Journal 732, 15, doi:10.1088/0004-637X/732/1/15 (2011)