The 2019 Subramanyan Chandrasekhar Prize in Plasma Physics

M. KIKUCHI, AAPPS-DPP CHAIR

The Division of Plasma Physics (Chair: Mitsuru Kikuchi) under the Association of Asia Pacific Physical Societies (President: Gui-Lu Long) has selected Professor Liu Chen of Zhejiang University/the University of California, Irvine and Professor Kazunari Shibata of Kyoto University as the sixth laureates of the 2019 S. Chandrasekhar Prize of Plasma Physics, which is awarded to scientists who have made seminal / pioneering contributions in the field of plasma physics. Professors Chen and Shibata will receive their respective awards at the 14th Asia Pacific Physics Conference, which will be held in Kuching, Malaysia.

Citations and a brief description of the respective achievements of the awardees will be listed below.

Liu Chen: For his pioneering and seminal theoretical contributions to the physics of both magnetic fusion and space plasmas; including, notably, geomagnetic pulsation theory, nonlinear gyrokinetic theory, *Alfvén* wave heating and kinetic *Alfvén* waves, toroidal *Alfvén* eigenmodes, "fishbone" and energetic particle modes, and the excitation of zonal flow in toroidal plasmas.

Prof. Liu Chen was born in 1946 in Hangzhou, China. He received his bachelor's degree from National Taiwan University in 1966, and received his PhD from the University of California (UC), Berkeley in 1972. After working at Bell Laboratory with A. Hasegawa, he worked in the Princeton Plasma Physics Laboratory (PPPL) (1974-1993). He then became a professor at UC Irvine (1993-2012) and since 2012 he has been an emeritus above-scale professor of physics at UC Irvine. Prof. Chen founded the Institute of Fusion Theory and Simulation in the Department of Physics, Zhejiang University, in 2006; since 2016, he has been the director emeritus of the institute.

He published a celebrated paper (JGR1974) with A. Hasegawa at Bell Laboratory on the theory of experimentally observed long-period magnetic pulsation in the magnetosphere, as a coupling between the solar wind perturbations at the magnetopause and the shear *Alfvén* waves. This paper has received 940 WoS citations and 1145 Google citations.

He developed a nonlinear gyrokinetic equation with E. Frieman while at PPPL (Phys. Fluids1982). This equation averages out fast gyroscopic motion to arrive at a kinetic equation for low frequency electromagnetic waves. Today, the nonlinear gyrokinetic equation is one of the most powerful equations in plasma physics. This paper has received 523 Web of Science (WoS) citations and 770 Google citations.

Prof. Chen also discovered key physics of *Alfvén* waves such as *Alfvén* waves heating through spatial resonance (PRL1974, Phys.Fluids1974) and kinetic *Alfvén* waves (PRL1975, Phys. Fluids1976) with A. Hasegawa. Prof. Chen also discovered fundamental physics of *Alfvén* wave – energetic particle interactions such as "fishbone" oscillation as an energetic particle-driven internal kink mode (PRL1984), prediction of EPM (energetic particle mode) in the *Alfvén* continuum (Phys. Plasmas1994), and the *Alfvén* eigenmode as a discrete gap mode (Ann. Phys. 1985).

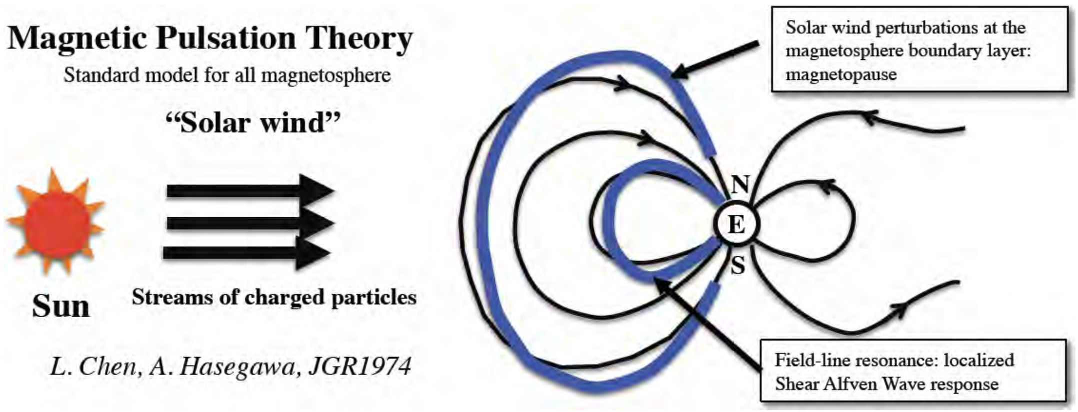

Fig. 1: Liu Chen's magnetic pulsation theory.

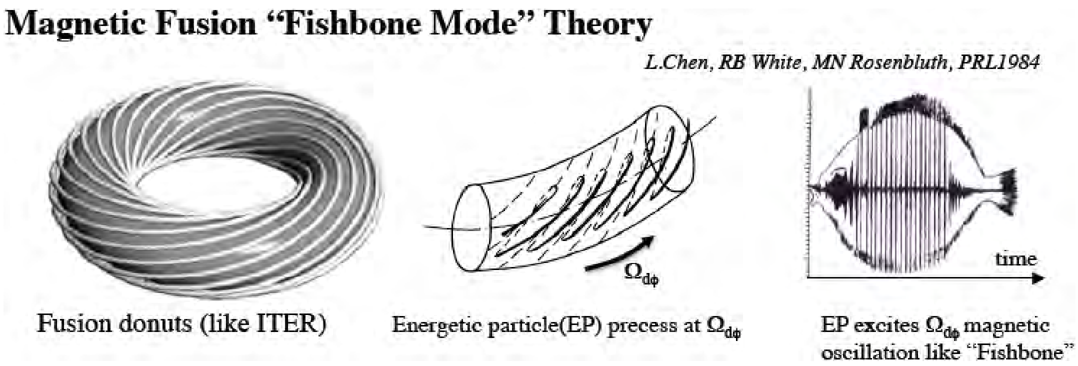

Fig. 2: Liu Chen's 'fishbone' mode theory.

Prof. Chen also successfully developed a theory of zonal flow driven by drift-wave turbulence in toroidal plasma using ballooning representation as a key mechanism of self-regulation of plasma turbulence (Phys. Plasmas2000).

Prof. Chen's total citation count is 10, 868 in the Web of Science with an H-index=54 and is 14,082 in Google Scholar citations with an H-index=61. Due to his outstanding research accomplishments, briefly illustrated above, he has been the recipient of a number of prestigious awards; notably, the J.C. Maxwell Prize from the American Physical Society in 2012 and the Hannes *Alfvén* Prize from the European Physical Society in 2008.

Kazunari Shibata: For his pioneering and seminal contributions in solar and astrophysical magnetohydrodynamics (MHD), including the first non-steady MHD numerical simulations of astrophysical jets from magnetic accretion disks; the discovery of coronal X-ray jets and chromospheric anemone jets in the solar atmosphere, and theories and numerical simulations for solar jets and mass ejections based on the MHD reconnection mechanism; his pioneering proposal of plasmoid-induced-reconnection and fractal reconnection; and his suggestion that superflares, observed on Sun-like stars, may also occur on the Sun.

Prof. Kazunari Shibata was born in 1954 in Osaka, Japan. He received his PhD from Kyoto University in 1983. After working at Aichi University of Education and the National Astronomical Observatory of Japan for 16 years, he became, and has been, a professor at the Kwasan and Hida Observatory of Kyoto University since 1999. He was the director of Kwasan and Hida Observatory from 2004 until this March (2019). He served the physics community as president of the Astronomical Society of Japan, from 2017-2019.

He, in collaboration with Prof. Y. Uchida, discovered the physical origin of astrophysical jets (PASJ1985, PASJ1986), i.e., that astrophysical jets are accelerated by the strong Lorentz force associated with the twisted magnetic field in the accretion disk. He also demonstrated the same mechanism working for the relativistic jets from black holes (Science 2002).

He discovered X-ray jets in the solar corona (as seen in the left panel of Figure 3) and X-ray plasmoid ejections from solar flares using the soft X-ray data observed by the Yohkoh satellite (PASJ1992, ApJL1995). He then developed a magnetic reconnection model of coronal X-ray jets (Nature1995) (as seen in the right panel of Figure 3). More recently, Prof. Shibata discovered smaller anemone-shaped jets in the solar chromosphere using the Hinode satellite's data (Science2007). Prof. Shibata proposed a unified model, i.e., the plasmoid-induced magnetic reconnection model, to explain all kinds of jets, solar flares, and even corona mass ejections (CMEs). The model has been recognized around the world. His unified reconnection model of solar flares, especially of jets, has revolutionized our understanding of solar eruptions.

In recent years, Prof. Shibata has been focusing on superflares on solar-type stars (as seen in Figure 4), and found that superflares 1000 times more energetic than the currently-largest solar flares may occur once in 5000 years on the Sun! This result has made a strong impact on the public since such an event will have profound influence on human life if it happens.

Prof. Shibata has published more than 290 papers in refereed journals. According to Google Scholar, these papers have been cited more than 21,000 times, and his H-index is 78. His total citation count in the Web of Science is ~14,000 and his H-index is 64. He has also trained tens of PhD students and many postdocs from Japan and other countries in the Asia-Pacific region, e.g., China and India. He was the recipient of FY2001 Chushiro Hayashi Prize of the Astronomical Society of Japan.

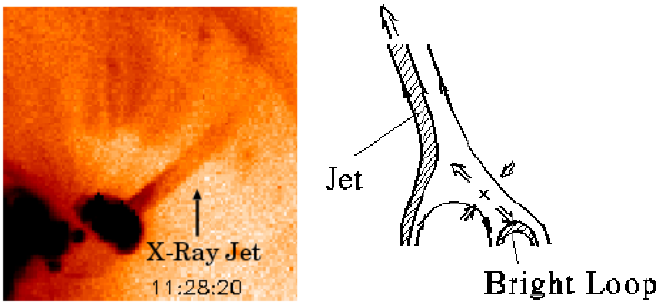

Fig. 3: Left: A soft X-ray jet in the solar corona; right: a theoretical model.

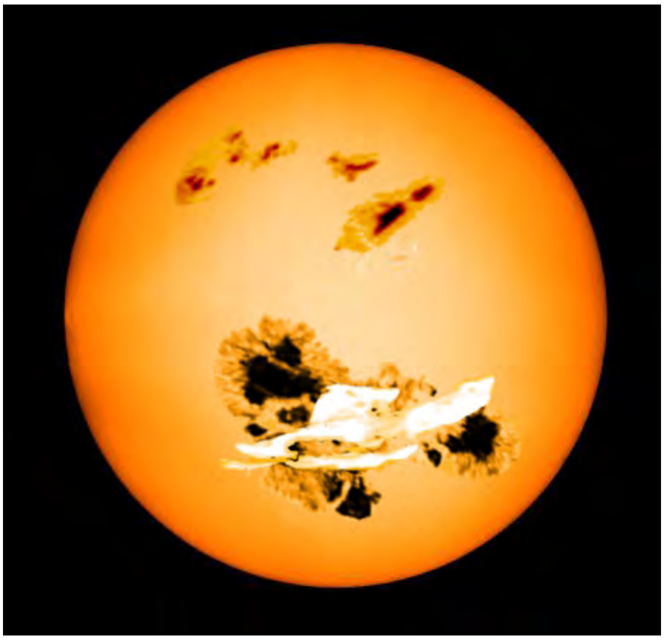
Fig. 4: An imagined superflare occurring on a solar-type star.