Press Release

July 30, 2018

Association of Asia-Pacific Physical Societies (AAPPS)

Division of Plasma Physics (AAPPS-DPP)

Subramanyan Chandrasekhar Prize of Plasma Physics

– Professor Toshiki Tajima is selected as Laureate of 2018 –

The Division of Plasma Physics (Chair: Mitsuru Kikuchi) under the Association of Asia Pacific Physical Societies (President: Gui-Lu Long) selected Professor Toshiki Tajima of the University of California at Irvine as the 2018 Laureates of S. Chandrasekhar Prize of Plasma Physics, which is awarded to scientists who have made seminal / pioneering contributions in the field of plasma physics. The S. Chandrasekhar Prize is an internationally authoritative annual prize awarded to an outstanding scientist (s) in the field of plasma physics as a basis for astrophysics or fusion research, and plasma applications. Award ceremony will be held at the 2nd Asia-Pacific Conference on Plasma Physics held in Kanazawa city from November 12-17 in 2018.

Citation: *For wide-ranging contributions to plasma physics, in particular for the discovery and invention of extremely intense (relativistic) laser-driven wakefields as robust and long-lasting plasma states, with broad impacts on high energy particle acceleration and other applications, including medicine; in which he exerted leadership to launch high field science and to form large new research communities.*

Prof. Tajima’s invention in the citation is now actively pursued as a revolutionary new technology to accelerate charges particles to high energy for elementary particle study as well as medical cancer therapy

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Press Release

On the Achievements of Professor Toshiki Tajima

Professor Toshiki Tajima (University of California at Irvine, U.S.A.)

Professor Toshiki Tajima is regarded as the father of laser-driven acceleration, as he invented the concept of Laser Wakefield Acceleration (LWFA) in plasma physics with John Dawson published in Physical Review Letters (1979). This paper received one of the highest citations in the entire field of plasma physics (WoS: 2927 cites, Google scholar: 4346 cites), reflecting its fundamental nature and broad impact.

Using his scheme, the accelerating field can be enhanced more than 6 orders of magnitude larger than the conventional scheme. He predicted even three more orders of magnitude higher field using the tabletop X-ray laser-driven plasma-accelerator. Hundreds of groups and thousands of researchers worldwide are hoping to revolutionize the high-energy physics beyond today's existing frontiers using his invention. His physics inventions are numerous such as the Relativistic Flying Mirror (RFM) to generate coherent X-ray pulse, the Radiation Pressure Acceleration (RPA) for the compact ion acceleration, and the application of this compact ion acceleration to the hadron therapy. His contribution in physics includes proving the properties of nonlinear vacuum predicted by quantum electrodynamics and explaining the mystery of the cosmic ray acceleration as well as the plasma astrophysics in general. Professor Subrahmanyan Chandrasekhar worked in wide variety of physics fields. We can see a similarity in Prof. Tajima's approach in sciences.

During 2002-2008, Prof Tajima served as Director General of Kansai Research Establishment of JAERI and Kansai Photon Science Institute (KPSI) of JAEA (now is QST). He served as Chairman for International Committee for Ultra Intense Lasers (ICUIL) during 2008-2016. He is recipient of Robert W. Hamilton Award (1997), Farrington Daniels Award (2005), Suwa Prize (2006), Nishina Memorial Prize (2006), The Blaise Pascal Chair awarded (2009), Einstein Professorship of Chinese Academy of Science (2013), Enrico Fermi Prize (2015), Academician (Foreign Member), Russian Academy of Sciences (2016). He has outstanding scientific records of Web of Science cites more than 16000 (H-index of 57) and Google scholar cites more than 23000 (H-index of 70).

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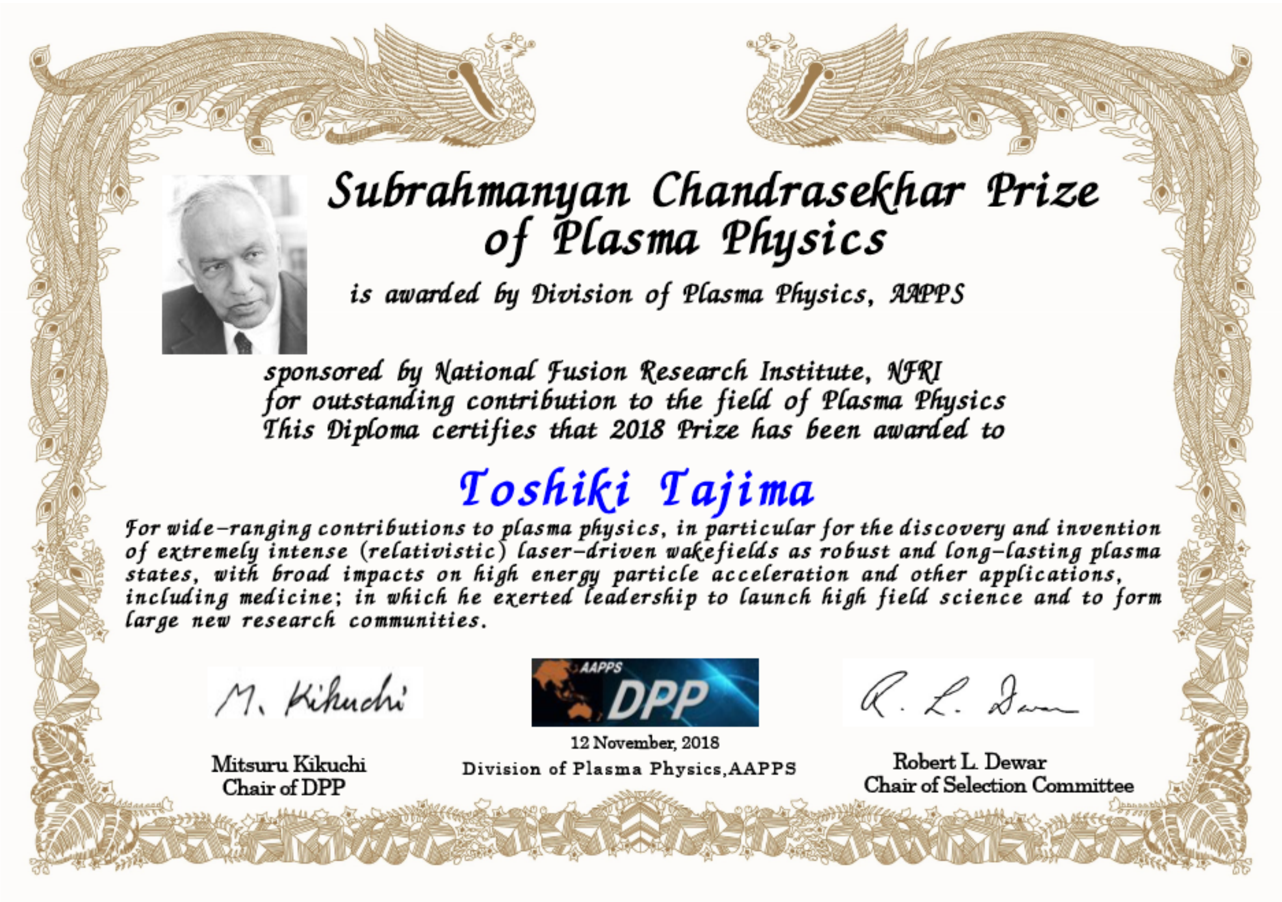
Appendix-1: 2018 S. Chandrasekhar Prize of Plasma Physics

The S. Chandrasekhar Prize (http://aappsdpp.org/AAPPSDPPF/prizetable.html) is an internationally authoritative annual prize awarded to an outstanding scientist (s) in the field of plasma physics as a basis of astrophysics or fusion research and so on selected at Asia-Pacific region. Similar level of internationally authoritative annual prizes are James Clarke Maxwell Prize in American Physical Society, Division of Plasma Physics (https://www.aps.org/programs/honors/prizes/maxwell.cfm) and Hannes Alfven Prize in European Physical Society, Division of Plasma Physics (http://www.epsnews.eu/2017/09/nomination-for-the-eps-hannes-alfven-prize-2018/).

Certificate and medal of 5th S. Chandrasekhar Prize will be given at the Second Asia-Pacific Conference on Plasma Physics in Nov 12-17 at Kanazawa, Japan.



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Appendix-2: Glossary

1. Subrahmanyan Chandrasekhar: Astrophysicist born in India. He received the Nobel Prize in Physics in 1983 *for his theoretical studies of the physical processes of importance to the structure and evolution of stars,* including the Chandrasekhar limit on the mass of white dwarf stars. His research covered several broad areas, as seen from his texts, which included *Principles of Stellar Dynamics* (1942), *Hydrodynamics and Hydromagnetic Stability* (1981), and an influential book based on his lecture notes in *Plasma Physics* (1960).

2. AAPPS: Association of Asia-Pacific Physical Societies(HP: http://www.aapps.org/main/index.php): The Association of physical societies in the Asia Pacific region founded by the Nobel Laureate in Physics C.N. Yang, and Professor Akito Arima in 1983. The AAPPS held the 12th Asia Pacific Physics Conference under the president (at that time) Shoji Nagamiya in Makuhari, Japan. The current president is Professor Gui-Lu Long, Tsinghua University, China.

3. AAPPS-DPP: Division of Plasma Physics, AAPPS(HP : http://aappsdpp.org/AAPPSDPPF/index.html): The first division under the AAPPS based on the success of the plasma physics program in the APPC-12. This division was formed in January 2014 based on the recommendation of Professor Nagamiya at the AAPPS council.

4. Subrahmanyan Chandrasekhar Prize of Plasma Physics : This plasma physics prize was founded by the AAPPS-DPP in July 2014. This prize is given to a plasma physicist annually for pioneering and/or seminal contribution to plasma physics. The 2014, 2015, 2016 and 2017 prize recipients were Professors S. Ichimaru, P. Kaw, D. B. Melrose, C. Z. Cheng & L.C. Lee (http://aappsdpp.org/AAPPSDPPF/prizetable.html). The 2018 prize is sponsored by NFRI (National Fusion Research Institute) in Korea.

The 2018 Selection Committee composed of leading plasma physicists in Asia-Pacific region. The chairman is Professor Robert Dewar (Australian National University). The members are, Professor Zensho Yoshida (The University of Tokyo), Professor Hideo Sugama (National Institute of Fusion Science), Professor Zheng-Ming Sheng (Shanghai Jiaotong University), Professor Xiao-Gang Wang (Harbin Institute of Technology), Professor Chan-He Nam (Gwangju Institute of Science and Technology), Professor Dong-Hun Lee (Kyung Hee University), Professor Donald B. Melrose (University of Sydney), Professor Ravindra Kumar (Tata Institute of Fundamental Research), Professor A.A. Mamun (Jahangirnagar University), Professor Kerchung Shaing (National Cheng Kung University), and Professor Lou C. Lee (Academia Sinica).

5. H-index: The definition of the index is that a scholar with an index of *H* has published *H* papers each of which has been cited in other papers at least *H* times.

6. Laser Wakefield Acceleration (LWFA): Particle acceleration method using the nonlinear electron plasma wave and relativistic effect. Ultra-short pulse lase can produce electrons approaching speed of light and bunching of electrons produces huge electric field ~200GV/m. LWFA is demonstrated recently in Lawrence Berkeley National Laboratory in the U.S. accelerating electrons over a distance of just ten centimeter up to 10GeV.

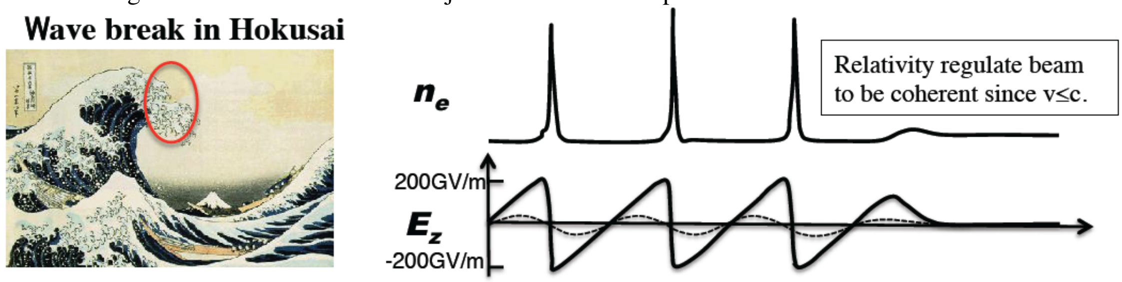

Figure 1: Hokusai's wave breaks but Tajima's wakefield will not break due to relativistic effect.

7. Relativistic Flying Mirror (RFM): Relativistic flying mirror in plasmas is thin, dense electron or electron-ion layers accelerated by high-intensity electromagnetic waves to velocities close to the speed of light in the vacuum. The reflection of the electromagnetic wave from the relativistic mirror results in its energy and frequency changes suitable for producing X-ray laser.

8. Radiation Pressure Acceleration (RPA): New method of accelerating ion by transfer of photon momentum to the ions. High radiation pressure forces electron clouds to move forward and creates intense electric field to accelerate ions.

9. Hadron Therapy: Radiation therapy is the medical use of ionizing radiation to treat cancer. When the irradiating beams are made of charged particles (protons and other ions, such as carbon), radiation therapy is called hadron therapy. Using the laser plasma acceleration, therapy machine can be made compact.

Wakefields: laser, toilet science, and gamma-ray bursts

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Wakefields are nonlinear, robust, and stable entities that appear when the phase velocity of the excited waves is high (such as the speed of light, in which case it provides a relativistic structure). Laser wakefield in gas is capable of providing accelerating fields over GeV/cm, while that in solid driven by a single-cycled X-ray laser amounts to TeV/cm [1]. Experimental demonstrations began since 1995, while its applications proliferated. The aspiration for laser wakefield acceleration has driven ever more intense lasers, which in turn opened up the scientific field of High Field Science. While wakefields are of a high phase velocity phenomenon, if we manage to irradiate laser on a target in such a way to coherently slow down (e.g. with a thin film), the wave with slower phase velocity is capable of accelerating heavier ions (radiation pressure acceleration) [2, 3].

We are led to the realization that wakefield is perhaps the strongest coherent and dynamic structure the Nature provides us. As long as certain conditions are fulfilled, the excited wake in gas can be indestructible. Such a property is ideal to the application I would call “toilet science”, i.e. the science to take care of the downstream waste after use (in this case high energies of spent beams) to adequately and nondestructively decelerate them over the shortest possible distance by wakefields [4, 5]. High energy particles may be stopped over a short distance without the beam dump radioactivated.

When we turn our eye to the Universe, we also realize that the Mother Nature has excited robust wakefields. In fact she had created wakefields before we did in our laboratories. In the accretion disk of a black hole (BH) (or a neutron star (NS)) we surmise that the magneto-rotational instability in the disk can cause a chunk of matter to accrete toward the central object, which triggers disruptive jet excitations that give rise to the wakefield acceleration along the jets. Thus high energy electrons can become gamma ray bursts [6]. Professor Barry Barish showed that disruptive accretion toward the compact star (BH or NS) emits gravitational waves, followed by gamma-ray bursts [7].

Finally, to visit a fusion plasma, in a Field Reverse Configuration plasma experiment where the magnetic field is weak and allows global particle orbits the strong ion beam injection is observed to excite large amplitude ion cyclotron (IC) waves. Because the beam-driven IC waves have high phase velocity, the high amplitude IC wave shows the ubiquitous wakefield saturation amplitude of the Tajima-Dawson field $E_{TD} = M\,\Omega_{ci} v_{ph} / q$. This is an ion branch of wakefield [8].

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