



Reviews of Modern Plasma Physics: Volume 7

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Abstract

This is the editorial of Volume 7 published in 2023 whose papers are from several Topical Collections and invited and contributed ones. Authors were speakers at AAPPS-DPP Annual Conferences 2020, 2021, and 2022 and some are from individual submissions. While Volume 1–Volume 5 are relatively selective with 10–15 papers published in each volume, Volume 6 have published 41 papers. Now, we have 32 review papers published in Volume 7, where the short summaries of each paper are given below.

Keywords Plasma physics · AAPPS-DPP · RMPP

1 Introduction

Reviews of Modern Plasma Physics (RMPP) is the review journal specialized in plasma physics and official journal of AAPPS-DPP. Our journal has six article types, i.e., “Review” broadly reviewing related works all over the world, “Special Topics” focused on one’s/group’s own works, “Tutorial” for beginner-friendly paper, “History” for scientific history, “Chandrasekhar Lecture”, and “Plasma Innovation Lecture” for lecture on Laureate’s contribution. Details can be found at <https://www.springer.com/journal/41614/submission-guidelines>. Editor-in-chief, chief, associate editors, and guest editors are responsible in managing this journal.

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2 Volume 7 publication

Series of papers are proposed by Editorial board of Magnetic Fusion Plasma Physics (led by JQ Dong) in 2021 are published as topical collection “MF BoE recommendation 2021” (Marinoni et al. 2021), and five new papers published in 2023 (Xiao et al. 2023; Hu et al. 2023; Xu et al. 2023; Dong et al. 2023; Ida 2023).

Xiao et al. (2023) reviewed Supersonic Molecular Beam Injection (SMBI) invented by Dr L. Yao in Southwestern Institute of Physics (SWIP) for efficient fueling, edge plasma control, and physics studies, such as perturbed particle and heat transport, ITB control, stimulated L-H transition, ELM mitigation, pedestal control, divertor heat load control, and its application in many magnetic fusion devices world-wide.

Hu et al. (2023) reviewed Li application as plasma facing materials via coating, injection, flowing liquid limiter in EAST tokamak for more than 10 years supporting its long-pulse high performance [for long pulse operation, see Figure 10 in Kikuchi et al. (2019)]. Paper includes Li coating techniques, plasma Li-wall interaction, Lower hybrid wave (LHW) H-mode access with Li wall, ICRF heating improvement with Li-wall, ELM suppression with Li-wall, application of Li granules, and liquid Li.

Xu et al. (2023) summarized impurity-induced small/no ELM H-mode regimes focused on EAST tokamak, which is one of the directions to mitigate divertor damage in ITER and fusion reactors. Paper introduces typical behavior, operational window, compatibility with high bootstrap current fraction and radiative diveror, mechanism of small grassy ELM, and no ELM regime with impurity injection.

Dong et al. (2023) reviewed three [Fokker–Planck, BBGKY, and Quasi-linear (or Klimontovich)] approaches on collision process in uniformly magnetized plasmas. Key elements are separating velocity changes into Δv^c by E and Δv^B by B for binary collision (BC), separating collision term into Coulomb collision and pair correlation terms to reach magnetized Balescu–Lenard–Guernsey (BLG) equation from three approaches.

Ida (2023) reviewed isotope effects on transport stressing variety of isotope physics categorizing into primary and secondary effects rather than unified view as scaling laws for main and impurity particle convection, zonal flow, and Reynolds and residual stress. He also discussed isotope mixing as well.

Topical collection “Selected papers from AAPPs-DPP2021 MF1 and MF2 Plasma sessions” is organized by Hiroshi Yamada and Jiaqi Dong from MF1 and MF2 speakers in AAPPs-DPP2021 (Urano 2022; Eliseev et al. 2022; Wang et al. 2022; Shikama 2022) and published four new articles in 2023 (Ding and Garofalo 2023; Zhang et al. 2023; Hillairet 2023; Bisai and Sen 2023).

Ding and Garofalo (2023) reviewed highlights of the high poloidal beta (β_p) regime research on DIII-D in past decade in view of realizing steady-state fusion power plant Kikuchi (1990) and Fusion Pilot Plant. Paper presents realization of key needs for attractive reactor scenario in DIII-D and projection to future devices.

Zhang et al. (2023) reviewed control and mitigation of runaway electron (RE) for disruption prediction and runaway electron physics using massive gas

injection (MGI), shattered pellet injection (SPI), resonant magnetic perturbation (RMP), SMBI, and laser blow-off injection (LBO) in HL-2A and J-TEXT toward contribution to ITER machine protection.

Hillairet (2023) gave broad review of Ion Cyclotron Range of Frequency (ICRF) systems, experiments, modeling during last 20 years. Paper includes heating schemes (minority heating, higher harmonics, and 3-ion schemes), detrimental effects (impurity production, arcs), ICRF system, and recent topics (impurity mitigation in metallic wall, loading in ELMy operation, and long-pulse operation). For earlier ICRF research, see Chapter 6 of Kikuchi et al. (2012).

Bisai and Sen (2023) reviewed comprehensive theories and experiments on “Blob”, especially contribution by him and IPR giving their picture of “Blob” as break-up of streamers by flow shear as special topics. Paper includes consolidated account of their Blob formation criterion compared with experimental data in TORPEX, NSTX, and ADITYA devices.

Topical collection “Nonlinear Processes in Solar-Terrestrial Plasmas” is organized by Tohru Hada, Abraham Chian, and Ryoji Matsumoto selected from SG and SA speakers in AAPPS-DPP2021 (Nariyuki 2022; Dominguez and Utz 2022; Chian et al. 2022; Parashar and Matthaeus 2022) and new four articles published in 2023 (Hori et al. 2023; Morton et al. 2023; Wang et al. 2023; Parks et al. 2023; Rempel et al. 2023).

Hori et al. (2023) reviewed types of rotating MHD waves [Magnetic-Coriolis (MC) waves] present in planetary dynamos especially the torsional Alfvén waves and the magnetic Rossby waves, which could be possible probing method for the processes within the dynamos in rotating MHD fluid. Understanding the planetary magnetic variations, length-of-day variations, and possibly the surface appearance in gaseous planets are expected by the probing with those waves. Data-driven technique like dynamic mode decomposition (DMD) enables wave detection from geomagnetic data.

Morton et al. (2023) reviewed Alfvénic waves in solar atmosphere introducing Alfvén surface modes, conversion of core p(pressure)-mode to Alfvénic waves, double mode conversion in the lower solar atmosphere, wave damping mechanisms (phase mixing of radially varying Alfvén resonance), Kelvin–Helmholtz instability, and Alfvénic wave turbulence. The waves journey by the large-scale inhomogeneity, wealth of fine structure through chromosphere, and corona are highlighted.

Wang et al. (2023) reviewed ion- and electron-scale magnetic reconnection, turbulent magnetic reconnection studies via multiple spacecraft mission. With four-point MMS spacecraft measurement, all terms in generalized Ohm’s law could be calculated. Observations of magnetic flux ropes, magnetic islands, and plasmoids during magnetic reconnection in different geometries are also reported. For turbulent reconnection, see Lazarian, Space Science Review (2012) Lazarian et al. 2012.

Parks et al. (2023) reviewed Alfvén [Space Science Review(1967)]-Falthammar [Rev. Geophys (1977)] ideas on current and electric fields in solar-terrestrial plasmas dedicated to passing of Falthammar (2022). Double-layer description is of interest. G. K. Parks also contributed to RMPP Parks et al. 2017 which is first paper published in RMPP on June 2017.

Rempel et al. (2023) reviewed various Lagrangian methods to detect Coherent Structure in complex space plasma velocity and magnetic fields. Concept of Lagrangian Coherent Structure (LCS) can be used to better understand complex plasma phenomena in the solar atmosphere. Integrated averaged current deviation (IACD) can accurately find the boundary of magnetic vortices. LCS is also discussed in magnetic fusion plasmas in particular reversed-field pinch Pegoraro et al. 2019.

Topical collection “Kinetic Alfvén waves (Hasegawa and Chen 1975; Chen et al. 2021) in space, solar, and laboratory plasmas (KAW)” is organized by Yu Lin, Fulvio Zonca, and De-Jin Wu selected from CD (Kinetic Alfvén Wave) speakers in AAPPS-DPP2021 (Duan et al. 2022) and four new articles published in 2023 (Dai and Wang 2023; Lysak 2023; Liu et al. 2023; Qiu et al. 2023). Kinetic aspect of magnetic reconnection is also reviewed by L. C. Lee’s Chandrasekhar lecture (Lee and Lee 2020).

Dai and Wang (2023) reviewed the magnetosphere reconnection theory, modeling and in-situ observations, and relation between Hall effect in magnetosphere and KAW eigenmode. Paper showed that various phenomena during magnetosphere magnetic reconnection [Hall electric and magnetic fields, field-aligned current (FAC), ion acceleration and energy conversion, turbulence by KAW, and fast reconnection] can be explained by KAW eigenmode perspective. KAW $n=1$ eigenmodes with quadrupole Hall magnetic field, combined KAW $n=0$ eigenmodes with bipolar Hall magnetic field are introduced to explain symmetric ($n=1$) and asymmetric ($n=1+0$) magnetic reconnection.

Lysak (2023) reviewed auroral electron acceleration by KAW and broad band energy spectrum at ionospheric Alfvén resonator in Earth and Jupiter. Paper explains extended theory of KAW, transferring energy to small scale (turbulent cascade, ionospheric feedback instability, and phase mixing), formation of ionospheric Alfvén resonator (IAR) due to large density variation parallel to auroral flux tube, quasi-periodic bursts of field-aligned electrons, and KAW in the IAR.

Liu et al. (2023) summarized nonlinear gyrokinetic simulations of reversed shear Alfvén eigenmodes (RSAE) excited by energetic particles in DIII-D. Paper highlights self-generated zonal flows dominate the RSAE nonlinear saturation, and nonlinear saturation due to the formation of coherent phase space structures that flatten the EP distribution function at resonances.

Qiu et al. (2023) reviewed nonlinear saturation of TAE via wave–wave coupling. Paper stresses essential role of nonlinear gyrokinetic theory to understand those process. Nonlinear TAE saturation through modulational instability of zonal field (similar to zonal flow but distinctly different radial mode structure), through parametric decay and frequency cascade, and through TAE–drift wave coupling were presented clearly. This paper came also from his plenary talk in AAPPS-DPP2022.

Topical collection “High energy density physics” is organized by Kunioki Mima, Jie Zhang, Ryosuke Kodama (Sun et al. 2022), and three new articles published in 2023 (Zhao et al. 2023; Morita and Fujioka 2023; Kuramitsu et al. 2023).

Zhao et al. (2023) reviewed theoretical and numerical studies on mitigation of parametric instabilities by broadband lasers and led to a conclusion that about 1% bandwidth is required for efficient mitigation of laser–plasma interactions (LPI’s). Understanding of broadband effect of LPIs is of fundamental interest for achieving

inertial confinement fusion (ICF). This paper came from plenary talk given by Zheng-Ming Sheng in AAPPS-DPP2021.

Morita and Fujioka (2023) reviewed the magnetic field generation ($> 100T$) via laser-driven coils and its measurements with different approaches, which are essential for its applications in high energy density plasma. The physical models of magnetic field generation via the laser-driven micro-coils are presented and compared to experimental results.

Kuramitsu et al. (2023) reviewed electron-scale magnetic reconnections in laser produced plasma in both simulations and experiments with Biermann magnetic fields driven by high power lasers, with or without external DC magnetic fields. Understanding electron dynamics in magnetic reconnection is essential to fully understanding this process as multi-scale phenomena. This paper came from his topical plenary talk at AAPPS-DPP2020 SA session.

Topical collection “Turbulence” is organized by Patrick H. Diamond and two articles published in 2023 (Gürçan 2023; Alexakis 2023).

Gürçan (2023) reviewed wave number space network theory in plasma turbulence. This is pretty new approach in plasma turbulence with example on modulational instability, Hasegawa–Mima/Hasegawa–Wakatani systems, relation to magnetic shear and ballooning transform, network models such as nested polyhedra models (NPMs), spiral chain model, shell model, small-world network shell model, and application of wave number space network to 3D turbulence such as Navier–Stokes equations and MHD.

Alexakis (2023) reviewed quasi-two-dimensional turbulence in neutral fluids and MHD plasmas. As we know, 2D turbulence has quite different dynamics compared with 3D turbulence such as Kraichnan–Leith–Batchelor dual cascade. Paper stressed recent discovery that two behaviors can coexist with a simultaneous transfer of energy both to large and to small scales, and dynamics of transition from 2D to 3D turbulence in thin-layer turbulence.

Topical collection “Selected papers from AAPPS-DPP2021 Basic and Applied Plasma sessions” is organized by Gunsu Yun, Yan Feng, Rajdeep S. Rawat, Sudeep Bhattacharjee, and Jianjun Shi selected from Basic and Applied speakers in AAPPS-DPP2021 (Attri et al. 2022; Gupta 2022; Liu et al. 2022) and two new articles published in 2023 (Fu et al. 2023; Ouyang et al. 2023).

Fu et al. (2023) gave a comprehensive review of the similarity and scaling laws for different type of low-temperature discharges and similarity laws were thoroughly investigated for discharge breakdown phenomenon and fully developed self-sustaining discharges, such as glow discharges, pulsed discharges, streamers, radio-frequency discharges, and microdischarges.

Ouyang et al. (2023) summarized progress and the development of material modification, deposition, and etching based on low-temperature plasma technique for the materials in ESC (electrochemical energy storage and conversion) devices.

Topical collection “Chandrasekhar Lecture” is lecture series of Chandrasekhar Prize laureates (Ichimaru 2017; Kaw 2017; Melrose 2017; Tajima et al. 2020; Lee and Lee 2020; Chen et al. 2021; Park et al. 2022).

A new Chandrasekhar Lecture by Choudhuri (2023) reviewed the flux transport dynamo model which successfully explained 11-year sunspot cycle and its

anomaly. He actually spent some time in University of Chicago with Prof. S. Chandrasekhar as well as recently passed Eugene Parker. This lecture paper is well written for non-expert of solar plasma physics how he approached sunspot cycle physics Choudhuri et al. (1995).

Fukumoto and Zou (2023) reviewed isomagnetovortical (kinematically accessible) perturbation and wave energy in flowing MHD (ideal and extended MHD) by an extension of Arnold's hydrodynamic theorem on steady Euler flow against isovortical perturbation, and showed linkages among various concepts (Arnold's isovortical variation, dynamically accessible variation (DAV), Frieman–Rotenberg equation, time evolution of DAV, and wave energy). This paper came from his invited talk in AAPPs-DPP2021 F session.

Yokoi (2023) reviewed role of cross-helicity (velocity-magnetic field) in magnetic field induction and momentum transport in MHD turbulence using four Green functions. Cross-helicity effects in dynamo, comparison between cross-helicity effect and differential rotation effect in spherical shell, generation and dissipation mechanisms of turbulent cross-helicity, cross-helicity effect in stellar dynamos, flow generation by cross-helicity, and cross-helicity effects in magnetic reconnection are reviewed. This paper came from his invited talk in AAPPs-DPP2021 F session (Table 1).

Zhang et al. (2023) reviewed kinetic instabilities in photo-ionized plasmas via intense laser and its diagnostic. Paper addresses simulation, experiment, and measurement of photo-ionization via tunnel ionization under combined Coulomb and Laser potential, formation of highly anisotropic electron velocity distribution to excite kinetic instabilities, such as two-stream instabilities, current filamentation instability, and Weibel instability and its relaxation, self-organization of magnetic field via current filamentation, and Weibel instabilities, measurement of Biermann battery field, and formation of magnetic helicoids by circularly polarized lasers. This paper came from AAPPs-DPP2022 CD topical plenary talk by Chandrasekhar Joshi.

Mendonca (2023) reviewed quantum Landau damping and quantum trapping in nonlinear quantum plasma. He discussed how quantum plasma formulation can be applicable to classical plasmas such as photon Landau damping and quasi-particle turbulence. This paper came from his invited talk AAPPs-DPP2022 Basic-session. For quantum plasmas, see also Manfredi et al. (2019) and Melrose (2020), Topical Collection “New Aspects of Quantum Plasma Physics” by A.A. Mamun (<https://link.springer.com/collections/hbcdjfaejc>) (Manfredi et al. 2021; Hossain and Mandal 2022; Mannan 2022; Brodin and Zamanian 2022; Misra and Brodin 2022; Haas and Mahmood 2022; Masood et al. 2022).

Fujisawa et al. (2023) gave Sanae-Inoue Itoh memorial note for her scientific history on fundamental and fusion plasma theory, especially on plasma bifurcation such as L- to H-mode bifurcation by radial electric field, zonal flow and streamer, nonlinear coupling, and energy transfer in plasma turbulence. She was also interested in application of statistical theories such as Mori's projection method to strong plasma turbulence (see Chapter 6 of Diamond et al. (2020)). She was active member of 2019 S. Chandrasekhar Prize selection committee just before she passed away.

Table 1 Review papers published in Volume 7 of RMPP

| Ist Author | References | Article type | Collection |
|---------------------|---------------------------|----------------|--|
| Yao Zhao | Zhao et al. (2023) | Review | HEDP; https://link.springer.com/collections/gbdbfgjjcf |
| Guolian Xiao | Xiao et al. (2023) | Special Topics | MF-BoE2021; https://link.springer.com/collections/fcbhadehdi |
| Lei Dai | Dai and Wang (2023) | Review | KAW; https://link.springer.com/collections/ftedabdbfj |
| Siye Ding | Ding and Garofalo (2023) | Special Topics | MF2021; https://link.springer.com/collections/gbgehbaeih U40; https://link.springer.com/collections/hdngbbiahb ST; https://link.springer.com/collections/adeajhhha |
| Kumiko Hori | Hori et al. (2023) | Special Topics | KAW; https://link.springer.com/collections/ftedabdbfj |
| Robert L. Lysek | Lysek (2023) | Review | Regular (DPP2021-Fundamental) |
| Yasuhide Fukumoto | Fukumoto and Zou (2023) | Special Topics | MF-BoE2021; https://link.springer.com/collections/fcbhadehdi |
| Jiansheng Hu | Hu et al. (2023) | Special Topics | BA2021; https://link.springer.com/collections/ccdfjgdef |
| Yangyang Fu | Fu et al. (2023) | Review | Regular(Fundamental) |
| Hans Schamel | Schamel (2023) | Special Topics | MF2021; https://link.springer.com/collections/gbgehbaeih |
| Yipo Zhang | Zhang et al. (2023) | Special Topics | HEDP; https://link.springer.com/collections/gbdbfgjjcf |
| Hiroki Morita | Morita and Fujioka (2023) | Review | U40; https://link.springer.com/collections/hdngbbiahb , MF-BoE2021; https://link.springer.com/collections/fcbhadehdi |
| Guosheng Xu | Xu et al. (2023) | Special Topics | BoE2021; https://link.springer.com/collections/ftedabdbfj |
| Pengfei Liu | Liu et al. (2023) | Special Topics | KAW; https://link.springer.com/collections/ftedabdbfj |
| Julien Hillairet | Hillairet (2023) | Special Topics | MF2021; https://link.springer.com/collections/gbgehbaeih |
| Richard Morton | Morton et al. (2023) | Special Topics | ST; https://link.springer.com/collections/adeajhhha |
| Arnab Rai Choudhuri | Choudhuri (2023) | Chandrasekhar | Chandra; https://link.springer.com/collections/gcjdhbaija |
| Chao Dong | Dong et al. (2023) | Review | MF-BoE2021; https://link.springer.com/collections/fcbhadehdi |
| Özgur D. Gürcan | Gürcan (2023) | Review | Turb.; https://link.springer.com/collections/aahfhdceifh |
| Akihide Fujisawa | Fujisawa et al. (2023) | History | Regular |
| Nirmal K. Bisai | Bisai and Sen (2023) | Special Topics | MF2021; https://link.springer.com/collections/gbgehbaeih |
| Katsumi Ida | Ida (2023) | Review | MF-BoE2021; https://link.springer.com/collections/fcbhadehdi |

Table 1 (continued)

| Ist Author | References | Article type | Collection |
|---------------------|-------------------------|----------------|--|
| Yasuhiro Kuramitsu | Kuramitsu et al. (2023) | Review | HEDP; https://link.springer.com/collections/gbdbfgjgjc |
| Jose Tito Mendonca | Mendonca (2023) | Review | Regular(DPP2022-Basic) |
| Rongsheng Wang | Wang et al. (2023) | Review | ST; https://link.springer.com/collections/hdhgbbiahb |
| Zhiyong Qiu | Qiu et al. (2023) | Special Topics | KAW; https://link.springer.com/collections/hdhgbbiahb U40; https://link.springer.com/collections/hfedabdbfj |
| Bo Ouyang | Ouyang et al. (2023) | Review | BA2021; https://link.springer.com/collections/ccdfjgdef |
| George K. Parks | Parks et al. (2023) | Review | ST; https://link.springer.com/collections/adeajhhha |
| Alexandros Alexakis | Alexakis (2023) | Review | Turb.; https://link.springer.com/collections/aahfudcifh |
| Erico L. Rempel | Rempel et al. (2023) | Special Topics | ST; https://link.springer.com/collections/adeajhhha |
| Nobumitsu Yokoi | Yokoi (2023) | Review | Regular (DPP2021-Fundamental) |
| Chaojie Zhang | Zhang et al. (2023) | Review | Regular (DPP2021-Fundamental) |

Schamel (2023) summarized his own scientific efforts for more than 50 years on coherent electron and ion hole structure in Vlasov–Poisson plasmas, nonlinear dispersion relation (NDR), gallery of elementary modes, electron holes, and ion holes as “Special Topics”. His pioneering works have been recognized, for example, in Hutchinson (2017).

Topical collection “U40 winner papers (U40)” is papers of AAPPS-DPP Young Researcher Award winners and published two articles in 2019 Takahashi 2019; Feng 2019, one in 2020 Zhong et al. (2020), one in 2021 Choi (2021) and five in 2022 (Wang 2022; Takeda et al. 2022; Wang et al. 2022; Zhou et al. 2022; Amano et al. 2022), and three in 2023 (Ding and Garofalo 2023; Xu et al. 2023; Qiu et al. 2023).

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Data availability No data is used in this article

Declarations

Conflict of interest The author is the Editor in Chief of Reviews of Modern Plasma Physics.

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