Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PEM26-P01 Room:Convention Hall Time:May 24 18:15-19:30

Investigation of Energetic Particle Hybrid Simulation Model

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Energetic particle populations coexisting with the thermal gas are commonly found in space plasma environments. Although the number density of the energetic particles is usually much lower than the thermal population, the energy density is often substantial. Typical examples include the thermal gas and galactic cosmic rays in the interstellar medium, a cold plasma originating from the ionosphere and the energetic ring-current population in the inner magnetosphere.

The typical scale sizes such as the Larmor radius between the two population are vastly different, making it important to take into account kinetic effect of energetic particles even for the macroscopic dynamics in which the fluid approximation for the thermal population is adequate. The difference in scale size makes it impractical to deal with both the components in a fully kinetic manner.

Here we propose a method that deals with only the energetic particles as a kinetic population whereas the fluid approximation is used for the thermal gas. We will demonstrate that this may be achieved as a natural extension of our recently developed quasi-neutral two-fluid plasma simulation code. Several preliminary simulation results will be discussed to investigate the validity of the model.

Keywords: numerical simulation, plasma, cosmic rays

PEM26-P02 Room:Convention Hall Time:May 24 18:15-19:30

Nonlinear evolution of MRI studied by an MHD code with the compact difference scheme and the LAD method

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The magnetorotational instability (MRI) is one of the most important phenomena in the accretion disk. Turbulence generated by MRI causes the turbulent viscosity in the disk and is a strong candidate of the driver of mass accretion. Recent study suggested that the turbulence induced by MRI also plays an important role in the planetesimal formation in the protoplanetary disk. In the planetesimal formation process, both the ionized gas and dusts coexist in the disk and the motion of dusts is strongly affected by the motion of gas through collisional and/or frictional effects. Kato et al. (2010;2012) showed the possibility that meter-sized dusts are gathered locally due to the modification of the disk gas distribution through the evolution of MRI and that situations favored for the planetesimal formation are created in the localized region. In addition to the effect pointed out by this simulation, we should take into account effects through the Kelvin-Helmholtz instability (Sekiya, 1998; Barranco, 2009) and the streaming instability (Youdin & Goodman, 2005) generated by the dust-gas interaction as well as the time evolution of the global disc structure (Suzuki et al., 2010). In order to carry out the MHD simulation considering these effects, we need to develop the scheme that can accurately resolve both short wavelength waves in turbulence and discontinuity appeared in the evolution of instabilities.

In the present study, we develop an MHD simulation code using an 8th-order compact difference scheme with the local artificial diffusivity (LAD) method (Kawai, 2013). The compact difference scheme proposed by Lele (1992) enables us to solve turbulent flow accurately up to the wavenumber range corresponding to a few grid points. The LAD method for MHD simulation proposed by Kawai (2013) enables us to reduce unphysical oscillations generated in central difference type scheme like the compact difference scheme. We have also applied parallelization by MPI using the pipeline algorithm to the code in order to increase the box size with keeping the high spatial resolution. By using the pipeline algorithm, we have applied the domain decomposition to the code with maintaining the accuracy of the compact difference scheme. We carry out a series of standard test problems for MHD simulations and clarify pros and cons of the developed MHD code for the study of MRI. By conducting spatially 2-dimensional test problems, we find that the maximum value of the numerical error appeared in the computation of the divergence of the magnetic field is the order of 10^{-12}, which is approximately consistent with the results of Kawai (2013).

We then carry out the 3-dimensional MHD simulation of MRI by the developed code. In order to realize the differential rotation, we use the shearing box boundary condition (Hawley et al., 1995) and the 9-wave method (Dedner et al, 2010) so as to suppress the divergence error caused by the interpolation in the shearing box boundary. We initially set the uniform vertical magnetic field and assume the perturbation in the three-components of the velocity vector whose amplitude is 1% of the sound speed. Our developed simulation code can solve the linear growth and nonlinear evolution of MRI. Our newly developed code enables us to solve the MRI driven turbulence accurately, which is important in solving not only a wide range of the evolution of the disk but also the fine structure of the saturation and nonlinear evolution mechanism of MRI. We show the characteristics of the developed code and study results of the 3-dimensional MHD simulation of the nonlinear evolution of MRI.

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Yin-Yang Dynamo Simulation with in-situ visualization Using ParaView/Catalyst

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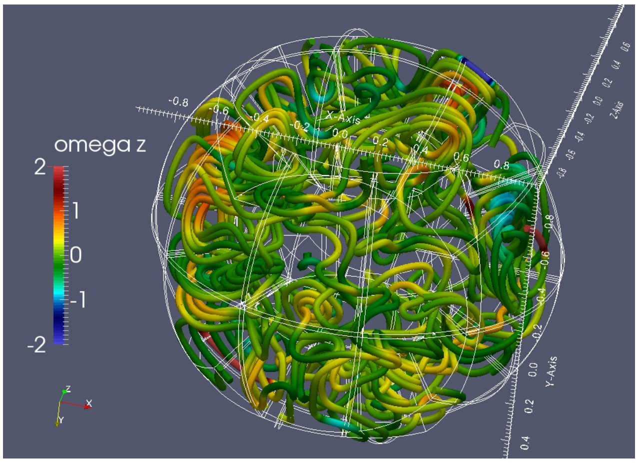
In accordance with the development of high performance computers, the data size of large scale simulations is exponentially growing. The post process visualization, which is currently the major approach to the data analysis in computer simulation research, might be in deadlock in the near future. The in-situ visualization method is attracting attention as a solution to this problem. We have recently realized an in-situ visualization of a magnetohydrodynamic (MHD) dynamo simulation using the Yin-Yang grid. We have used ParaView and Catalyst for visualization engine and its interface to the MHD simulation code for the in-situ visualization.

Keywords: Visualization, in-situ visualization, Yin-Yang grid



PEM26-P04 Room:Convention Hall Time:May 24 18:15-19:30

PIC simulations on magnetic perturbation around the Solar Probe Plus spacecraft

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For future space exploration, it is necessary to predict the nature of spacecraft-plasma interactions in extreme plasma environmental conditions. As one of such activities, we study on the physics of spacecraft-plasma interactions in the near-Sun environment. The spacecraft environment immersed in the solar corona is characterized by the small Debye length due to its high density (7000 /cc) and a large photo-/secondary electron emission current emitted from the spacecraft surfaces, which lead to much different nature of spacecraft-plasma interactions from that in the near-Earth environment. Consequently, the spacecraft charges negatively near the Sun unlike usual photo-emitting spacecraft in the near-Earth environment. In the present study, we reproduce the plasma environment around the Solar Probe Plus satellite planned by NASA by means of numerical simulations based on the Particle-in-cell method. We report recent research progress on near-spacecraft magnetic perturbations, which is generated by a complex current closure around the spacecraft.

Keywords: spacecraft-plasma interaction, solar coronal plasma, spacecraft charging, photoelectron emission, magnetic perturbation, PIC simulation

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Electron temperature anisotropy during compression of current sheets thicker than the ion skin depth

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Collisionless magnetic reconnection drives explosive release of magnetic energy to kinetic and thermal energy of plasmas in space plasma phenomena, such as solar flares and convection of plasmas and magnetic fields in the Earth's magnetosphere. Satellite observations in the Earth's magnetotail have shown that an initial current sheet ten times thicker than the local ion skin depth gets as thin as the ion skin depth, when magnetic reconnection is triggered in the sheet. According to the linear analysis of the tearing instability, the thicker the thickness of current sheets is, the exponentially lower the growth rate is, while the stronger the anisotropy of plasmas is, the higher the growth rate is. Current sheets can be thin due to the Dawn-Dusk electric field associated with the convection of magnetic fields in the Earth's magnetosphere and effects of the lower-hybrid drift instability. However, it is not fully understood how magnetic reconnection is triggered in a current sheet much thicker than the ion skin depth.

In this study, we perform the current sheet thinning by using the one-dimensional PIC simulation imposed the Dawn-Dusk electric field at boundaries with various initial parameters. We investigate the dependence on the initial parameters of the strength and the distribution of the anisotropy and of the compression level of current sheets. The results show that (1) the distribution of the anisotropy changes with the initial thickness of current sheets, (2) the strength of the anisotropy at the center of current sheets is explained by the adiabatic heating perpendicular to magnetic fields regardless of the initial parameters, (3) the compression level of current sheets normalized by the local ion skin depth is much lower than the ratio of the terminal strength of the lobe magnetic field to the initial strength of that. These results can be useful to understand processes of the current sheet thinning and the trigger of magnetic reconnection in multidimensional simulations including the tearing instability and/or the lower-hybrid drift instability.

Keywords: magnetic reconnection

PEM26-P06 Room:Convention Hall Time:May 24 18:15-19:30

Validity of gyro-averaging method for oblique whistler-mode wave particle interaction

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We perform test particle simulations of energetic electrons interacting with oblique whistler-mode waves in the Earth's magnetic field. We first solve exact equations of motion of test electrons under the electric and magnetic fields of obliquely propagating coherent wave with right-hand polarization. In this test, the energetic electrons undergo multiple cyclotron resonances. We also apply gyro-averaging method by treating electron motion as its guiding center motion to simplify the complicated cyclotron motion [1,2]. The result shows that the gyro-averaging motion is successfully consistent with the direct motion of the electron. Applying this result we can just use the guiding center motion of electrons to represent the completed motion of electrons. Therefore, these method can be utilized in the particle simulations of oblique propagation waves to reduce the relativistic equations of motion and minimize the computation resources, which makes simulations of multiple particles more feasible.

References

[1] Bell (1984), The nonlinear gyroresonance interaction between energetic electrons and coherent VLF waves propagating at an arbitrary angle with respect to the Earth's magnetic field. *J. geophys. Res.* 89, 905.
[2] Nunn and Omura, A computational and theoretical investigation of nonlinear wave particle interactions in oblique whistlers, Submitted to *J. Geophys. Res.*.

Keywords: whistler-mode wave, oblique propagattion

PEM26-P07 Room:Convention Hall Time:May 24 18:15-19:30

Effects of the alpha-proton drift velocity on alpha firehose instabilities in the solar wind

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In situ measurements have shown that the less-abundant alpha particles are characterized by temperature anisotropy which could drive the anisotropy-driven kinetic instabilities in the solar wind. In the collisionless limit, the differential alpha-proton flow velocity usually has finite value of the order of the local Alfven velocity. The presence of such differential flow may affect the properties of dispersion relations for anisotropy-driven instabilities. By making use of linear Vlasov theory, the present study investigates the effects of the alpha-proton drift velocity on firehose instabilities driven by parallel temperature anisotropy of alpha particles. It is found that for parallel firehose mode the dispersion properties are asymmetric in that the maximum growth rate is larger for forward propagating mode than for backward propagating one in the proton rest frame. For both parallel (forward propagating mode) and oblique firehose instabilities overall growth rates increase as the alpha-proton drift velocity increases. Consequently, the firehose instability thresholds are distinctly influenced by the presence of the alpha-proton drift velocity.

Keywords: firehose instability, solar wind ions, the alpha-proton drift

PEM26-P08 Room:Convention Hall Time:May 24 18:15-19:30

Vlasov simulation of the Rayleigh-Taylor instability

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The Rayleigh-Taylor instability (RTI) develops at an interface between two fluids with different densities when an external force is applied from a heavy fluid to a light fluid. In the previous studies of ideal MHD simulations, the RTI develops symmetrically in the horizontal axis. On the other hand, previous hall-MHD and Finite-Larmor-Radius (FLR)-MHD simulations have shown that the RTI develops asymmetrically in the horizontal axis. In this study, we perform four-dimensional Vlasov simulations of the RTI with two spatial dimensions and three velocity dimensions. We vary the ratio of the ion inertial length and/or the ion gyroradius to the spatial scale of the density gradient layer, and discuss the effect of the non-MHD effects on the growth of the RTI.

Keywords: Rayleigh-Taylor instability, Vlasov simulation, space plasma

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3-dimentional electromagnetic particle simulations about the low frequency component of Broadband Electrostatic Noise

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According to PIC simulations, ESW (Electrostatic Solitary Waves) are generated from electron beam instabilities. ESW correspond the upper frequency component of BEN (Broadband Electrostatic Noise) which is frequently observed in space plasma. The generation mechanism of the low frequency component of BEN, however, is still unexplained.
To clarify whether such low frequency waves are generated, we made statistical analysis on generation conditions of low frequency component of BEN observed by Electric Field Detector (EFD) onboard Geotail spacecraft. We detected low frequency component of BEN automatically from EFD data, and made an occurrence frequency distribution of these waves. Low frequency component of BEN are observed in PS and PSBL region in the magnetosphere.
We studied several plasma parameters at the time when low frequency component of BEN were observed, and found that these waves were observed in the conditions with low ion density and strong B field in these regions. Then, based on these statistical analysis, we are going to perform a series of three-dimensional electromagnetic particle simulations with different parameters on PC-Cluster built in our laboratory.

Keywords: particle simulations, low frequecy component of BEN, Geotail, EFD

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Test-particle simulation of electron elastic collision with neutral H2O molecule originated from Enceladus

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Water group neutrals (H_2O, OH, and O) in Saturn's inner magnetosphere play the dominant role in loss of energetic electrons and ions because of abundance of the neutral particles [e.g., Paranicas et al., 2007; Sittler et al., 2008]. The observations of injected electrons and ions in the inner magnetosphere suggest that these particles do not survive very long time due to the neutral cloud originated from Enceladus [e.g., Paranicas et al., 2007; 2008]. Thus, the previous study suggested that the neutral cloud contributes to loss processes of plasma in the inner magnetosphere. However, little has been reported on a quantitative study of the electron loss process due to electron-neutral collisions.

In the present study, we examine the variation of energetic electron pitch angle distribution at the magnetic equator and loss rate of precipitated electrons into Saturn's atmosphere through pitch angle scattering due to elastic collisions with neutral H_2O along Saturn's dipole magnetic field line around Enceladus. We conduct one dimensional test-particle simulation for monoenergetic electrons along Saturn's dipole magnetic field line around Enceladus when the co-rotating electron flux tube passes the dense H_2O region in the vicinity of Enceladus (˜6.4 minutes). The initial electron pitch angle distribution is assumed to be isotropic. In case of 1 keV electron, Tadokoro et al., [2014] showed that

1. the equatorial electron pitch angle distribution near the loss cone (<20 degrees and >160 degrees) decreases with time through pitch angle scattering due to elastic collisions and that the distribution around 90 degrees shows significant scattering due to the dense region of H_2O,

2. It is found that the electrons of ˜19 % to the total number of equatorial electrons at the initial condition are lost in ˜380 seconds.

3. The calculated loss time is fourth faster than the loss time under the strong diffusion.

We also show the loss rates through pitch angle scattering of electrons with not only 1 keV but also several hundreds eV ? several tens of keV.

Keywords: Test particle simulation, elastic collision, Enceladus, Saturn

PEM26-P11 Room:Convention Hall Time:May 24 18:15-19:30

Ion kinetic effects to nonlinear processes of the Kelvin-Helmholtz instability

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The nonlinear evolution of the Kelvin?Helmholtz (KH) instability at a transverse velocity shear layer in an inhomogeneous space plasma is investigated by means of a four-dimensional (two spatial and two velocity dimensions) electromagnetic Vlasov simulation. When the rotation direction of the primary KH vortex and the direction of ion gyro motion are the same (i.e. the inner product between the vorticity of the primary velocity shear and the magnetic field vector is negative) there exists a strong ion cyclotron damping. In this case, spatial inhomogeneity inside the primary KH vortex is smoothed and the secondary Rayleigh?Taylor/KH instabilities are suppressed. It is also found that another secondary instability on the electron inertial scale is simultaneously generated at secondary shear layers for both cases, but at different locations. The small-scale secondary instability takes place only when the inner product between the vorticity of the secondary shear layer and the magnetic field vector is positive, suggesting the damping of small-scale processes by ion gyro motion. These results indicate that secondary instabilities occurring in the nonlinear stage of the primary KHI show different evolutions depending on the sign of the inner product between the magnetic field and the vorticity of the velocity shear layer. The difference of the nonlinear evolution depending on the ion-to-electron mass ratio is also discussed.

Keywords: Kelvin-Helmholtz instability, computer simulation, Vlasov equation, non-MHD