
Transitioning AMPS to the CCMC

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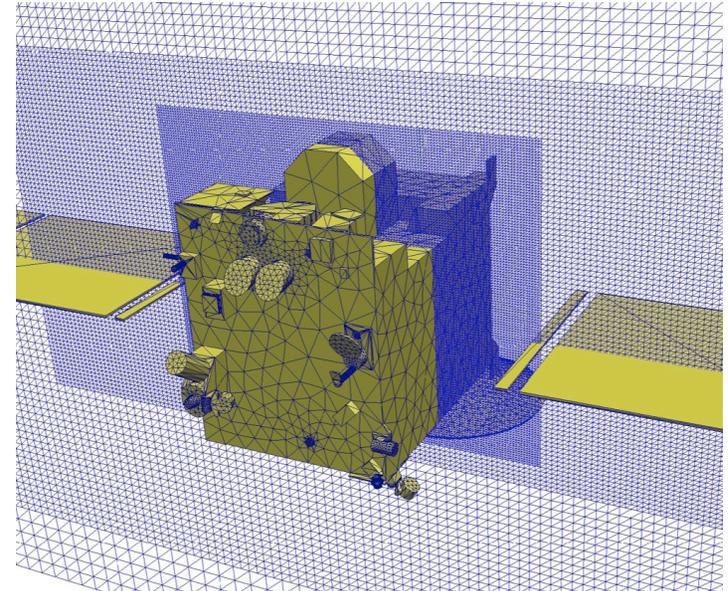
Adaptive Mesh Particle Simulator (AMPS)

- Adaptive Mesh Particle Simulator (AMPS)
 - Fully three dimensional
 - Numerical Scheme: Direct Simulation Monte Carlo (DSMC)
 - Modeling of the neutral and charged species, neutral and charged dust
- Kinetic description
 - Boltzmann equation
 - The evolution of the system is modeled by tracing the model particles
- Two phase flow modeling
- Included processes
 - Electron impact, charge exchange, photolytic reactions
 - Charting of the dust grains



Adaptive Mesh Particle Simulator (AMPS)

- Applications
 - Comets, planetary satellites and exospheres
 - Tracking of the ions and charged dust
- Integrated with SPICE and SWMF
- Optimizations
 - Local time step and particle weight
 - Individual particle weight correction
- Domain discretization
 - Adaptive Mesh Refinement (AMR) with cut-cells
- Parallel implementation
 - Domain decomposition
 - Static (volume, cell number) and dynamic load balancing (particle number, execution time)
 - Hybrid implementation: MPI (between nodes) + OpenMP (within each node)



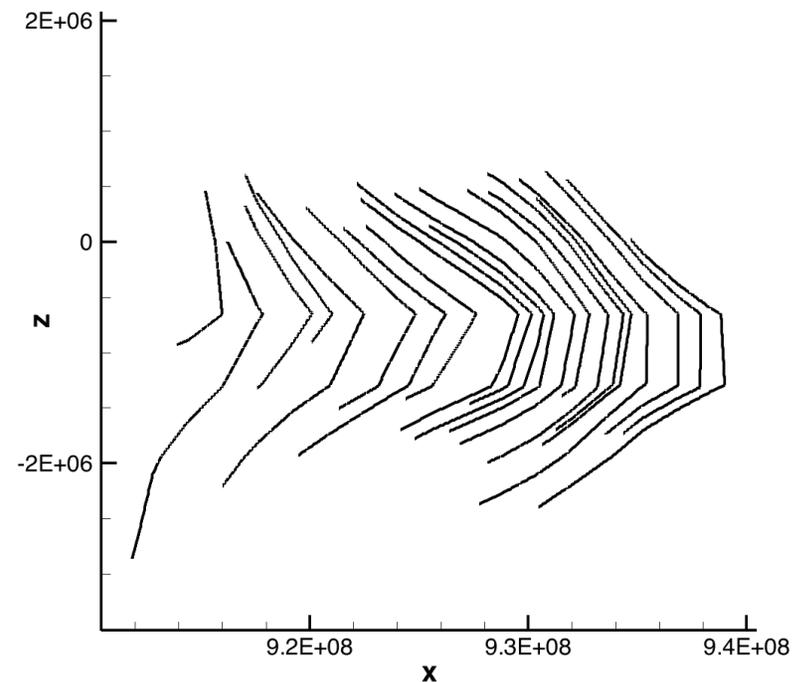
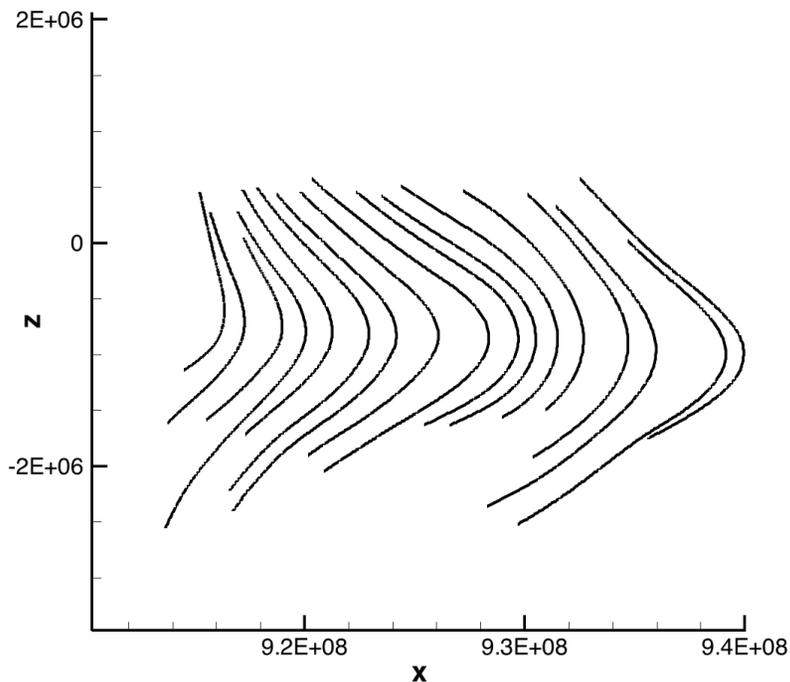
AMPS in CCMC

- Analyze charged particle trajectories moving in plasma
 - Post processing tool: use pre-calculated plasma and magnetic field
- Import of the plasma flow simulations into AMPS
 - Time-dependent results of the plasma modeling is saved in files
 - Kameleon is used for interpolating of the plasma model into AMPS' mesh
- Results provided by AMPS
 - Individual particle trajectories
 - Samples of the distribution functions
- Particle trajectory integration in AMPS
 - Boris
 - Guiding center
 - Particle tracking along a magnetic field line



AMPS in CCMC

- Electric and magnetic fields are interpolated onto a particle location
 - 2nd order interpolation (Borovikov et al., 2015)
- Example of particle trajectories calculated with 2nd order and a piecewise constant interpolations of the electric and magnetic fields:



User Interface

- A prototype of the web based user interface is under testing

← → ↻ ccmc.gsfc.nasa.gov/requests/PP/user_registration.php

COMMUNITY COORDINATED MODELING CENTER

Related Links | Frequently Asked Questions | Community Feedback | Downloads | Sitemap

About | Models at CCMC | Request A Run | View Results | Instant Run | Metrics and Validation | Education | RT Simulations

Step 1: Generate a Registration Number for each Requested Run and select the Model.

Registration Number
The Registration Number is composed of your first name (GivenName), your last name (FamilyName), date (yyyymmdd), model type (GM - Global Magnetosphere, IT - Ionosphere/Thermosphere, SH - Solar/Heliosphere, PP - Postprocessing), and run identification number (RunNumber):

GivenName_FamilyName_mmddyy_RunNumber, e.g., Lutz_Rastaetter_20160101_PP_1.

At the present time you are allowed to make up to 4 different submissions on the the same date (mmddyy). For each new submission made on the same date you need to choose a new **Run Number** ("1", "2", "3", "4", or "5"). Multiple submissions made on the same date with the same Run Number will overwrite the previous submission. You can use this feature to resubmit the request on the same date. If you decide to cancel or modify your submission at later date, please contact the CCMC staff:

e-mail: ror@ccmc.gsfc.nasa.gov
tel.: Masha Kuznetsova (+1) 301-286-9571, Lutz Rastaetter (+1) 301-286-1085.

Please have registration numbers when making inquiries about your requests. You will need your registration number to view the results when the simulations have finished.

First (Given) Name: (required)

Last (Family) Name: (required)

E-mail: (required)

Run Number:

Select a different Run Number if you have already requested any Magnetosphere Postprocessing run today (unless you want to overwrite the request)

Title/Introduction

Key words

Global Magnetosphere Post-Processing (PP) model:

AMPS

AMPS (version as of 2016/02/02)

Separatrix and Null Point Finder

Glocer (version as of 2016/02/02)

Next page: **Existing Run To Work on and Options**

AMPS



User Interface

- Initial parameters of the simulated trajectories

The screenshot shows the CCMC Community Coordinated Modeling Center website. At the top, there is a navigation bar with links: About, Models at CCMC, Request A Run, View Results, Instant Run, Metrics and Validation, Education, and RT Simulations. The main content area is titled "Particle start position input" and contains several sections:

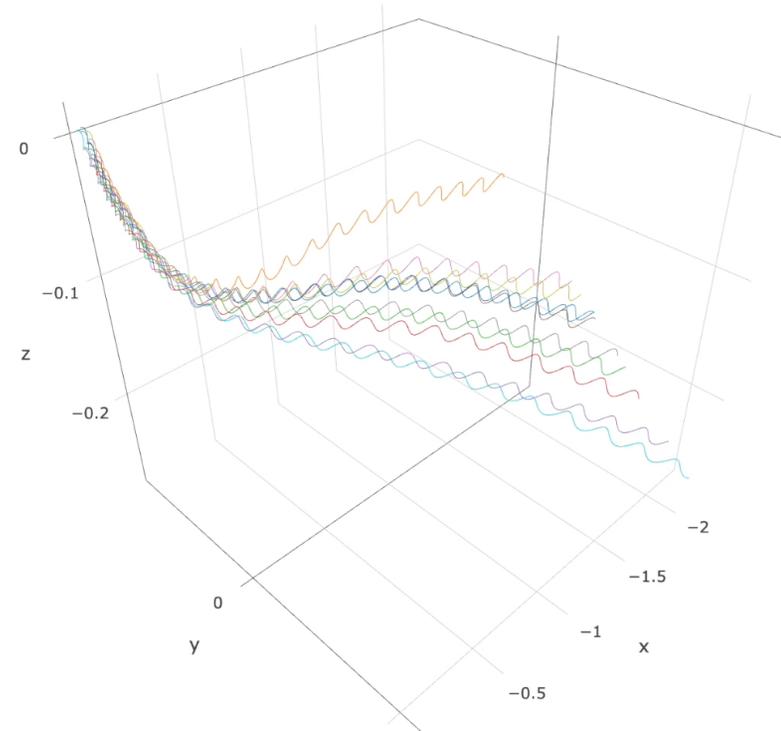
- Single particle position and velocity:** Includes input fields for X [R_E] (30.0), Y [R_E] (0.0), Z [R_E] (0.0), V_x [km/s] (-400.0), V_y [km/s] (0.0), V_z [km/s] (0.0), and a dropdown for Particle Species (p).
- Upload file with particle position, velocity and species:** Includes a "Choose File" button (No file chosen) and instructions: "The file size should not exceed 1Mb. Full path name to the particle position input file at your local disk should not contain any blank spaces or quotation marks. On DOS/Windows systems the recommended extension for the input file name is ".txt". Please read the detailed [instructions on particle input file format](#)".
- Initial particle data should be in GSM for SWMF, SM for LFM and GSE for GUMICS and OpenGGCM model runs to process**
- Spherical start region:** Includes input fields for X_{center} [R_E] (0.0), Y_{center} [R_E] (0.0), Z_{center} [R_E] (0.0), Sphere Radius R [R_E] (0.0), Bulk velocity V_s [km/s] (V=sqrt(VX²+VY²+VZ²)<298000) (-400.0), V_y [km/s] (0.0), V_z [km/s] (0.0), Temperature [eV] (<1 MeV) (10), and Number of particles N (≤ 1000) (100).
- Rectangular start region and particle distribution:** Includes input fields for X₀ [R_E] (30.0), Y₀ [R_E] (0.0), Z₀ [R_E] (0.0), X₁ [R_E] (30.0), Y₁ [R_E] (0.0), Z₁ [R_E] (0.0), V_x [km/s] (-400.0), V_y [km/s] (0.0), V_z [km/s] (0.0), Temperature T [eV] (<1MeV) (0.0), and Number of particles N (≤ 1000) (100).

Below these sections is a "Select run to work on" section with a "Magnetosphere run name" input field (search for runs; GUMICS runs are not supported yet) and "Submit" and "Reset" buttons. A registration number is displayed: "The Registration Number For This Run Is: Val_T_20160410_PP_1". A note says: "Please have the registration number when making inquiries about the run." At the bottom, there are logos for NASA, JPL, and other participating institutions.



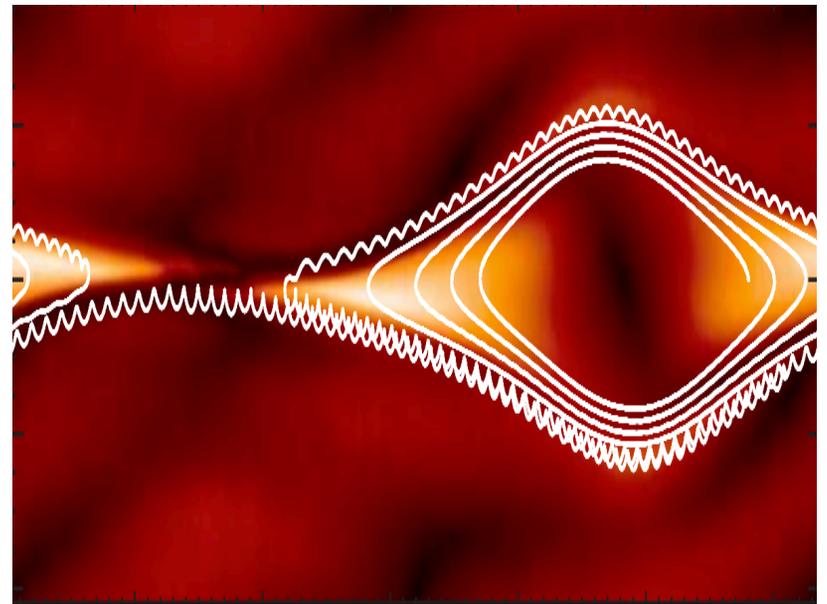
Visualization of the calculated trajectories

- Both desktop and browser viewers
- Visualization of the background model data
 - Cut-planes
 - Field line
- Visualization of the particle trajectories
 - Time slider
 - Particle trails
 - Annotated color bars



Example: Electron Acceleration

- Electron acceleration at magnetic islands during a reconnection (Drake, 2006)
- Background MHD simulation (Guidoni, DeVore and others, GSFC)
 - Plasma dynamics during a solar flare
- Electron trajectories along closed field lines
 - Particles are attached to the field line
 - Guiding center motion
 - Field lines extracted from MHD data (magnetic flux function)
 - Time (linear) and space (2nd order) interpolation
- Results
 - Energy gain $\approx 2-3$



Configuration of a magnetic island (Drake, 2006)



Conclusion

- Adaptive Mesh Particle Simulator
 - Self-sufficient Direct Simulation Monte Carlo model
 - A component of SWMF
 - A particle tracking tool in CCMC
- Application
 - Tracking of the charged particle trajectories, and sampling of distribution functions
 - Kinetic modeling of the charge particle dynamics moving in ambient plasma
- User interface and visualization components under testing
- More to come....

