Background generator v.00

User Guide

Annotation

The present code is developed for calculating the two-dimensional equilibrium magnetoplasma configuration of the planar or bent current sheet, satisfying one of the exact solutions of the Vlasov-Maxwell equations, derived by Harris, Kan, Fadeev, Manankova, Yoon and Lui, and Semenov, which all have been collectively generalized in the paper of Korovinskiy et al. (2018, Ann. Geophys., 36, 641–653).

I. The folder "cpp" contains:

1. The folder "bin", storing the executable file "*.x", generated by compilation in Linux, and/or executable file "*.exe", generated by compilation in Windows.
2. The folder "build", storing the object and dependences files, generated by compilation in Linux.
3. The folder "include", containing the class definitions "class_bckg.h", "class_bckg_yoonsem.h", "class_bckg_kasko.h", "class_grid_2d.h", and common functions "common.h".
4. C++ code "main.cpp".

   The code creates a double array $QNT[dimq][dimx][dimz]$, storing the calculated values of the magnetoplasma quantities of the background configuration: Ψ (magnetic potential), ρ (mass density), P_g (gas pressure), magnetic field components B_x, B_y, B_z, and plasma bulk velocity components V_x, V_y, V_z. The coordinate system: GSE, rotated for 180˚ around the z axis. The work plane is xz. Array QNT is stored in grid-format in file "background.grid", the configuration parameters are saved in the text file "background.info" in the run directory, specified in file "setup_bckgr_rundir.dat".
5. Make-file "Makefile" with instructions for compiler in Linux.
6. Batch-script "sweep.bat", deleting the object file, and renaming and replacing the executable file, created by compilation in Windows.

II. The folder "info" contains

Papers with formulas. See equations (11–16) in Korovinskiy_et_al_2018_angeo (the kasko model), and equations (18–19) in Yoon_&_Lui(2005) (the yoonsem model), where in the latter one should make the substitution: $a \to -ae^{i\alpha}$ and $b \to be^{i\beta}$.

III. The folder "mat" contains

1. Files with the initial settings "setup_*.dat".
2. The Matlab scripts, generating these input files "writer_*.m".
3. The Matlab scripts, calculating the magnetoplasma quantities in specific models: "backgr_generator_yoonsem.m", "backgr_generator_kasko.m".
4. The Matlab script "plotter.m", loading and plotting the quantities, stored in a binary file in a grid-format. Optionally, this script may return the array QNT, vector x, and vector z. Optional arguments: the work directory name (default: '../run') and the name of the loaded file (default: "background.grid"). Two-, one-, and null-dimensional grids are legal.
5. The Matlab script "launcher.m", applied for testing the background configurations. The configuration parameters are read from files "setup_bckg_yoonsem.dat" or "setup_bckg_kasko.dat", while the parameters of the computational grid are specified within the file "launcher.m" itself.

   The following parameters are also specified there:

   <MODEL> = { 'YoonSem', 'Kasko' } – current sheet model name.

   <FigPlotMode> = {1, 0}, – switch of the plot mode for magnetoplasma quantities, on / off.

   <SelfControl> = {1, 0}, – switch of the plot mode for the numerically calculated (Matlab built-in function gradient) residual force components Fx, Fz and div(B), and the quantities saved in the file "background.grid". To plot the latter one should also set the parameter <SaveBckFile> to 1.

IV. The folder “run” contains setup-files:

1. The file storing the run directory name “setup_bckgr_rundir.dat”.
   If this file is empty, absent, or corrupted, then the name of the current directory is used (full path).
2. The file storing the initial settings “setup_bckg.dat”, which are

   a) The current sheet model name (accessible options: ‘yoonsem’, ‘kasko’);

   b) The number of evaluated magnetoplasma quantities $dimq$ (the range: 0 – 9);

   c) System of units (accessible options: $norm$, si, cgs);

   d) Normalization constants { L, B_0, N_0 } (see Paragraph V.3).

3. The files, storing the parameters of the specific configurations: “setup_bckg_yoonsem.dat” and “setup_bckg_kasko.dat”. Parameters are specified in normalized units.
4. The file, storing the parameters of the uniform two-dimensional computational grid “setup_bckgr_grid.dat”. The grid parameters are specified in normalized units. The scaling factor is specified separately in file “setup_bckg.dat”.

Names of all input/output files can be modified in the file “class_bckg.h” in function “assign_file_names”.

V. Parameters of the current sheet models

1. The signs of the parameters a, a_1 and a_2 are opposite to those in the papers, i.e. $a \to -a$ (yoonsem), and $a_1 \to -a_1$, $a_2 \to -a_2$ (kasko).
2. The correct work of the code is possible in the 1st and 4th quadrants only, i.e. for $x > 0$.
3. The normalization constants, fixed in file "setup_bckg.dat", are specified in non-system units:

   a) Thousands of kilometers, for the spatial scale L,

   b) Nanotesla, for the magnetic field B_0,

   c) Number of particles in a cubic centimeter, for the number density N_0.
4. In the files "setup_bckg_yoonsem.dat" and "setup_bckg_kasko.dat", the temperature is normalized for the value $T_0 = 2(T_i + T_e)$.

   Hence, the user-defined value of T_i cannot exceed 0.5.
5. The normalized quantity of the ion velocity, specified in files "setup_bckg_yoonsem.dat" and "setup_bckg_kasko.dat", becomes a free parameter of the model when normalized units are selected, since its real value $V_{norm} = |V_i/V_A| = 2(T_i/T_0) \cdot (d_p/L)$ cannot be calculated. Here, d_p is the proton inertial length. When some non-normalized units are selected, the value of V_i, specified in the input files, is ignored and replaced by the computed value V_{norm}. The sign of the specified quantity V_i is also ignored, the program assigns it automatically (in accordance with the specified coordinate system, $V_i < 0$).

VI. Compilation

For the correct compilation, the search directory "…/include" is to be specified.

See, e.g., the existing make-file:

CXXFLAGS := -I.$(pwd)/include

The make-file instruction "CXXFLAGS += -O2" reduces the size of the executable file 1.5 times.

The make-file instruction "CXXFLAGS += -std=c++11" is not mandatory.

File "include/common.h" contains the functions, specified in namespace "com". If such namespace exists in the project, one should make sure that functions are not redefined.

In particular, in this file the new maximal length of the file name,

#define FILENAME_UMAX 1024

Since the standard length FILENAME_MAX may occur insufficient.

VII. Run

The code is launched from that directory, where the file “setup_bckgr_rundir.dat” is stored. The executable file may be stored in any other directory. In the run directory, specified in “setup_bckgr_rundir.dat”, the following input files are to exist: “setup_bckgr_grid.dat”, “setup_bckg.dat”, and at least one of the files “setup_bckg_yoonsem.dat” or “setup_bckg_kasko.dat”.

Example:

Assume that we want to calculate current sheet parameters by “kasko” model in normalized units.

Assume that we have the directory “v_00/cpp/bin”, where the executable file “bg.00.x” is stored.

Assume that we have the directory “v_00/run”, where we place the input file “setup_bckgr_rundir.dat”. In this file we save the path “kasko/norm”.

We create folder “v_00/run/kasko/norm” (if not exist) and copy input files “setup_bckgr_grid.dat”, “setup_bckg_kasko.dat”, and file “setup_bckg.dat” in this directory. In the latter, we specify the model parameters:

```
### model name: {yoonsem, kasko}
#
kasko
#
### number of output quantities
#
9
#
### units: { norm, si, cgs }
#
norm
…
```

Now we can run the code:

Linux	Windows
> cd v_00/run	> cd v_00\run
> ../cpp/bin/bg.00.x	> ..\cpp\bin\bg.exe

The model parameters and calculated magnetoplasma quantities will be stored in the folder “v_00/run/kasko/norm” in text file “background.info” and in binary file “background.grid”, respectively.

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