BDISTRIB User Manual

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CHAPTER 1

Overview

This program computes efficiency-ordered distributions of magnetic fields as described in [1]. The main method is described on page 12, and some key definitions are given on page 9.

There are 3 surfaces, named 'plasma', 'middle', and 'outer', The 'plasma' surface can correspond to the outermost surface of a VMEC equilibrium, or it can be a plain circular toroidal surface. The name of the relevant surface appears as a suffix on most variables.

On each surface we use a poloidal angle u and a toroidal angle v, defined as in NESCOIL. The coordinate u lies in the range [0,1]. The stellarator has nfp identical toroidal periods, and an increase in v by 1 corresponds to 1 of these periods. Thus, v increases by nfp in a complete toroidal revolution. In the output file, there is an array v corresponding to one toroidal period, as well as an array vl corresponding to all nfp toroidal periods. Note that v is proportional to the standard cylindrical angle phi: phi = 2*pi*v/nfp. Generally, field lines are not straight in the (u,v) coordinates. On the plasma surface, u is identical to the VMEC poloidal angle divided by 2*pi, while the VMEC toroidal angle differs by a sign relative to v.

In the various variable names in the code and output file, 'r' refers to the position vector, not to a radius. In various arrays with a dimension of length 3, this dimension always corresponds to Cartesian coordinates (x,y,z).

The 'normal' quantities in the code and output file refer to the surface normal vector N = (dr/dv) cross (dr/du) as in the NESCOIL paper. Note that this vector does not have unit magnitude.

1.1 Required libraries

- LIBSTELL (for reading VMEC wout files)
- NetCDF (for writing the output file)
- LAPACK (for the SVD subroutine)

1.2 Questions, Bugs, and Feedback

We welcome any contributions to the code or documentation. For write permission to the repository, or to report any bugs, provide feedback, or ask questions, contact Matt Landreman at matt.landreman@gmail.com

CHAPTER 2

Theory

2.1 Requirements

CHAPTER 3

Input Parameters

In this section we describe all the parameters which can be included in the input namelist.

3.1 Resolution parameters

For any new set of surface geometries you consider, you should vary the resolution parameters in this section to make sure they are large enough. These parameters should be large enough that the code results you care about are unchanged under further resolution increases.

---

nu_plasma
Type: integer
Default: 64
When it matters: Always
Meaning: Number of grid points in poloidal angle used to evaluate the integral To do: XXX in the outer-to-plasma surface inductance matrix. Often 64 is a good value. It is resonable and common but not mandatory to use the same value for nu_plasma, nu_middle, and nu_outer.

---

nu_middle
Type: integer
Default: 64
When it matters: Always
Meaning: Number of grid points in poloidal angle used to evaluate the integral To do: XXX in the outer-to-middle surface inductance matrix. Often 64 is a good value. It is resonable and common but not mandatory to use the same value for nu_plasma, nu_middle, and nu_outer.

---

nu_outer
Type: integer
Default: 64
When it matters: Always

Meaning: Number of grid points in poloidal angle used to evaluate the integral To do: XXX in the outer-to-plasma surface and outer-to-middle surface inductance matrices. Often 64 is a good value. It is resonable and common but not mandatory to use the same value for nu_plasma, nu_middle, and nu_outer.

---

nv_plasma
Type: integer
Default: 64
When it matters: Always
Meaning: Number of grid points in poloidal angle used to evaluate the integral To do: XXX in the outer-to-plasma surface inductance matrix. A value of 64 is often good when the number of field periods is more than 1. A higher value like 256 may be needed when the number of field periods is 1. It is resonable and common but not mandatory to use the same value for nv_plasma, nv_middle, and nv_outer.

---

nv_middle
Type: integer
Default: 64
When it matters: Always
Meaning: Number of grid points in poloidal angle used to evaluate the integral To do: XXX in the outer-to-middle surface inductance matrix. A value of 64 is often good when the number of field periods is more than 1. A higher value like 256 may be needed when the number of field periods is 1. It is resonable and common but not mandatory to use the same value for nv_plasma, nv_middle, and nv_outer.

---

nv_outer
Type: integer
Default: 64
When it matters: Always
Meaning: Number of grid points in poloidal angle used to evaluate the integral To do: XXX in the outer-to-plasma surface and outer-to-middle surface inductance matrices. A value of 64 is often good when the number of field periods is more than 1. A higher value like 256 may be needed when the number of field periods is 1. It is resonable and common but not mandatory to use the same value for nv_plasma, nv_middle, and nv_outer.

3.2 Geometry parameters for the plasma surface

geometry_option_plasma
Type: integer
Default: 0
When it matters: Always
Meaning: This option controls which type of geometry is used for the plasma surface.

geometry_option_plasma = 0: The plasma surface will be a plain circular torus. The major radius will be R0_plasma. The minor radius will be a_plasma.

geometry_option_plasma = 1: Identical to option 0. (This option exists just for consistency with geometry_option_middle and geometry_option_outer.)

geometry_option_plasma = 2: The plasma surface will be the last surface in the vmec file specified by wout_filename.

R0_plasma
Type: real
Default: 10.0
When it matters: Only when geometry_option_plasma is 0 or 1.
Meaning: Major radius of the plasma surface, when this surface is a plain circular torus.

---

a_plasma
Type: real
Default: 1.0
When it matters: Only when geometry_option_plasma is 0 or 1.
Meaning: Minor radius of the plasma surface, when this surface is a plain circular torus.

---

nfp_imposed
Type: integer
Default: 1
When it matters: Only when geometry_option_plasma is 0 or 1.
Meaning: When the plasma surface is a plain circular torus, only toroidal mode numbers that are a multiple of this parameter will be considered. This parameter thus plays a role like vmec's nfp (number of field periods), and is used when nfp is not already loaded from a vmec file.

3.3 Geometry parameters for the middle surface

geometry_option_middle
Type: integer
Default: 0
When it matters: Always
Meaning: This option controls which type of geometry is used for the middle surface.

geometry_option_middle = 0: The middle surface will be a plain circular torus. The major radius will be the same as the plasma surface: either R0_plasma if geometry_option_plasma is 0 or 1, or Rmajor_p from the vmec wout file if geometry_option_plasma is 2. The minor radius will be a_middle.

geometry_option_middle = 1: Identical to option 0, except the major radius of the middle surface will be set by R0_middle.

geometry_option_middle = 2: The middle surface will computing by expanding the plasma surface uniformly by a distance separation_middle.

R0_middle
Type: real
Default: 10.0
When it matters: Only when geometry_option_middle is 1.
Meaning: Major radius of the middle surface, when this surface is a plain circular torus.

---

a_middle
Type: real
Default: 1.0
When it matters: Only when geometry_option_middle is 0 or 1.
Meaning: Minor radius of the middle surface, when this surface is a plain circular torus.

3.4 Geometry parameters for the outer surface

geometry_option_outer
Type: integer
Default: 0
When it matters: Always
Meaning: This option controls which type of geometry is used for the outer surface.

geometry_option_outer = 0: The outer surface will be a plain circular torus. The major radius will be R0_outer. The minor radius will be a_outer.

geometry_option_outer = 1: Identical to option 0.

geometry_option_outer = 2: The outer surface will be the last surface in the vmec file specified by wout Filename.

R0_outer
Type: real
Default: 10.0
When it matters: Only when geometry_option_outer is 1.
Meaning: Major radius of the outer surface, when this surface is a plain circular torus.

---

a_outer
Type: real
Default: 1.0
When it matters: Only when geometry_option_outer is 0 or 1.
Meaning: Minor radius of the outer surface, when this surface is a plain circular torus.

3.5 Other parameters

---

basis_set_option
Type: integer
Default: 1
When it matters: Always
Meaning: Determines which set of basis functions is used.

`basis_set_option` = 1: Use $\sin(2\pi[mu + nv])$ basis functions.

`basis_set_option` = 2: Use $\cos(2\pi[mu + nv])$ basis functions.

`basis_set_option` = 3: Use both $\sin(2\pi[mu + nv])$ and $\cos(2\pi[mu + nv])$ basis functions.

---

save_level
Type: integer
Default: 1
When it matters: Always
Meaning: Option related determining how many variables are saved in the `netCDF` output file. The larger the value, the smaller the output file.

`save_level` = 0: Save everything.

`save_level` = 1: Save everything except the inductance matrices.

References

[1] A. Boozer. *Nucl. Fusion*, **55**, 025001 (2015).