§12. Development of the New HINT Code: HINT2

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As a standard method to calculate the three dimensional MHD equilibrium, the assumption that perfect nested flux surfaces exist is widely used. In such a method, a magnetic coordinate system is directly constructed so as to satisfy the force balance, or, MHD equilibrium equation $\vec{J} \times \vec{B} = \nabla P$. As various types of MHD equilibrium, namely, low-shear three dimensional MHD equilibria with magnetic islands, three dimensional MHD equilibria with multiple magnetic axes, three dimensional MHD equilibria with zero rotational transform, two dimensional MHD equilibria with current hole near the magnetic axis, are experimentally obtained, however, such a standard technique based on the nested flux surfaces becomes not to be applicable. In order to treat MHD equilibria with magnetic islands and stochastic magnetic field, a relaxation method based on the dynamic equations of the magnetic field and pressure has been developed. The HINT code is one of such solvers [1], however, it is fairly difficult to use it because of its sophisticated code structure coming from applicability to various types of three dimensional MHD equilibrium.

In order to resolve this difficulty, the HINT2 code, a new version of HINT, has been created so that

1. HINT2 is so written in F90 that
   (a) the dynamic allocation has been used, so that the user con specify the dimension size through the input,
   (b) detail specifications according to F90 grammar have been done, so that the users can easily recognize the relations callers and called routines,
   (c) some basic parts are treated as modules, thus there are no confliction between them and other parts,
   (d) the users can quite easily understand the code structure and the meaning of the variables,
   (e) the users can quite easily modify the code,
2. Various types of the three dimensional configurations can be chosen through the input parameters.

The relation of the cylindrical coordinates (R, ϕ, Z) with the rotating helical coordinates (u^1, u^2, u^3) used in HINT2 is

$$\begin{aligned} R &= R_0 + \delta\cos(Mu^3) \\ &\quad + u^1\cos(hMu^3) + u^2\sin(hMu^3), \\ Z &= - \delta\sin(Mu^3) \\ &\quad - u^1\sin(hMu^3) + u^2\cos(hMu^3), \\ \phi &= -u^3 \end{aligned}$$

where R_0 is the major radius, M is the toroidal field period, h is the rotating pitch of the calculation box $(h = 0, 0.5, 1)$, δ is the parameter to determine the origin of the rotation of the calculation box ($\delta = 0$: planer axis, $\delta \neq 0$: spacial axis). Those 4 parameters and one parameter : $k(= 0.5, 1, \cdots, M)$ are determined as input parameters depending on the chosen configuration, where k is related to the domain of u^3 as $\mathcal{D}(u^3) = [0, (2\pi k)/M]$, so that

$$k = \begin{cases} 0.5 & : \text{ half pitch} \\ 1.0 & : \text{ one pitch} \\ M & : \text{ full torus} \end{cases}$$

As example, various configurations are specified as follows:

$$\begin{array}{lll} \delta = 0, & h = 0.5 & : \text{ planer axis Heliotron} \\ \delta \neq 0, & h = 0.5 & : \text{ Helias} \\ \delta \neq 0, & h = 1.0 & : \text{ Heliac} \\ \delta = 0, & h = 0 & : \text{ cylinder} \end{array}$$

[1] K.Harafuji, T.Hayashi, T.Sato, J.comp.phys., **81**, No.1, (1989), 169