Stellarator Theory Teleconference

Papers of the US/Japan JIFT Workshop on "Progress of theoretical analyses in three dimensional configurations" reviewed in this presentation:

Development and Applications of HINT2 code
to Helical System Plasmas
Y. Suzuki

3D fluid modeling of edge transport
with a Monte Carlo scheme:
(recent application of EMC3-EIRENE)
M. Kobayashi

Motion of high pressure cloud in torus
plasmas
R.Ishizaki

Recent Application of the PIES Code to Stellarators
D. Monticello

Development and Applications of HINT2 code to Helical System Plasmas
Y. Suzuki

HINT2 is mostly a F90 version of HINT

- F90, dynamic allocation, FORTRAN array statements (auto vectorize)
- Modular design - separate subprograms
- New rotating helical coordinates (rectangular)
- Coming soon: MHD stability (including Hall term) input will be generated, Boozer coordinates will be generated
- Coming later: anisotropic pressure and plasma flow

HINT2 is in testing phase and was compared with VMEC

- Why not compare with HINT?
- Comparison with fixed boundary VMEC had slight differences.
- Comparison with free boundary VMEC had significant differences.

3D fluid modeling of edge transport with a Monte Carlo scheme: (recent application of EMC3-EIRENE)

M. Kobayashi

EMC3-EIRENE is a code developed to model edge plasmas where the island or stochastic nature of the flux surface make creation of a flux coordinate system impossible or very difficult. Flux coordinates needed to accurately treat the large ratio of fluid transport coefficients in the parallel and perpendicular directions.

The fluid equations are cast in a form that looks like a steady state Fokker-Plank equation and solved by a Monte Carlo scheme:

Plasma fluid equations

<density>

$$\nabla_{\parallel} \cdot (n\boldsymbol{V}_{\parallel}) + \nabla_{\perp} \cdot (-D\nabla_{\perp} n) = S_p,$$

<momentum>

$$\nabla_{\parallel} \cdot (m_i n \boldsymbol{V}_{\parallel}\boldsymbol{V}_{\parallel} - \eta_{\parallel}\nabla_{\parallel}\boldsymbol{V}_{\parallel}) + \nabla_{\perp} \cdot (-m_i \boldsymbol{V}_{\parallel} D\nabla_{\perp} n - \eta_{\perp}\nabla_{\perp}\boldsymbol{V}_{\parallel}) = -\nabla_{\parallel} p + \boldsymbol{S_m},$$

<electron energy>

$$\nabla_{\parallel} \cdot (-\kappa_i \nabla_{\parallel} T_i + \frac{5}{2} n T_i \boldsymbol{V}_{\parallel}) + \nabla_{\perp} \cdot (-\chi_i n \nabla_{\perp} T_i - \frac{5}{2} T_i D \nabla_{\perp} n) = k(T_e - T_i) + S_{ei},$$

<ion energy>

$$\nabla_{\parallel} \cdot (-\kappa_e \nabla_{\parallel} T_e + \frac{5}{2} n T_e \boldsymbol{V}_{\parallel}) + \nabla_{\perp} \cdot (-\chi_e n \nabla_{\perp} T_e - \frac{5}{2} T_e D \nabla_{\perp} n) = -k(T_e - T_i) + S_{ee},$$

Fokker-Planck equation

$$\nabla_{\parallel} \cdot [\mathrm{a}_{\parallel} f - \nabla_{\parallel}(b_{\parallel} f)] + \nabla_{\perp} \cdot [\mathrm{a}_{\perp} f - \nabla_{\perp}(b_{\perp} f)] = S,$$

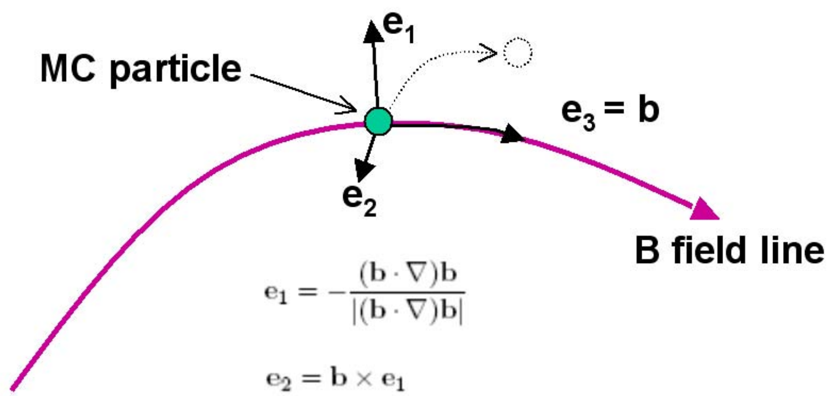
Using a Monte Carlo scheme and the local magnetic field line one can overcome the problem of the large ratio of the transport coefficients.

Jump step of Monte Carlo particle

$$\Delta \mathbf{x}_{\parallel} = \sqrt{2b_{\parallel}\Delta t}\,\overrightarrow{\xi_{\parallel}} + \mathbf{a}_{\parallel}\Delta t, \quad : \mathbf{e}_3$$

$$\Delta \mathbf{x}_{\perp} = \sqrt{4b_{\perp}\Delta t}\,\overrightarrow{\xi_{\perp}} + \mathbf{a}_{\perp}\Delta t, \quad : \mathbf{e}_1, \mathbf{e}_2$$

($\overrightarrow{\xi_{\parallel}}$ $\overrightarrow{\xi_{\perp}}$: 1D and 2D random unit vectors)



Applications to Textor Dynamic Ergodic Divertor and Local Island Divertor in LHD were presented and compared with experiment. Reasonable agreement was found for the ratio χ_{erg}/χ_{perp}, for the DED and for the temperature and density profiles for the LID.

Motion of high pressure cloud in torus plasmas

R.Ishizaki

- This presentation was a report on the efforts to model pellet injection in LHD plasmas.

- Want to explain the observation of the ablation cloud moving to the low field side of LHD. In addition want to explain the observed discrete nature of the ablation process.

- A 2-D axisymmetric pellet ablation code has developed. Not reported on here.

- A 3-D ideal MHD code has been developed to follow a cloud of ablated material in a 1/r field (a non-confining field). The cloud is observed to move to the low field side of the 1/r field. The velocity in the major radius has an oscillation and may be connected with the discreteness of the ablation process.

Recent Application of the PIES Code to Stellarators

D. Monticello

- Application of the PIES code to W7X was presented and it was showed that:

    1) The PIES code can be used in place of the MFBE code to calculate "self-consistent free boundary equilibrium". Comparison of the results of the two codes for the W7X experiment shows quite similar results.

    2) The PIES code can be initialized from the MFBE code.

- Application of the PIES code to TJ-II Ohmic current driven experiments was presented. Ohmic current has been found to affect confinement. Negative current gives the best performance and positive current the poorest performance measured in terms of the achieved density. We used PIES to investigate the possibility that this phenomenon is due to islands. We found that:

    The positive current case has poorer magnetic surface structure than the zero current case in agreement with experiment. However, the negative current case also has poorer magnetic surface structure than the zero current case in disagreement with the experiment.