TASK: Integrated Simulation Code

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Contents

• BPSI: Burning Plasma Simulation Initiative
• TASK: Core Code for Integrated Modeling
• Consideration on TASK/3D
• Summary
Burning Plasma Simulation

• Why needed?
  ◦ To predict the behavior of burning plasmas
  ◦ To develop reliable and efficient schemes to control them

• What is needed?
  ◦ **Simulation describing a burning plasma:**
    — **Whole plasma**  (core & edge & divertor & wall-plasma)
    — **Whole discharge**
      (startup & sustainment & transients events & termination)
    — **Reasonable accuracy**  (validation with experimental data)
    — **Reasonable computer resources**  (still limited)

• How can we do?
  ◦ **Gradual increase of understanding and accuracy**
  ◦ **Organized development of simulation system**
BPSI: Burning Plasma Simulation Initiative

Research Collaboration among Universities, NIFS and JAEA

Since 2002
Targets of BPSI

• **Framework** for collaboration of various plasma simulation codes
  - **Common interface** for data transfer and execution control
  - **Standard data set** for data transfer and data storage
  - **Reference core code**: TASK
  - **Helical configuration**: included

• **Physics integration** with different time and space scales
  - **Transport during and after a transient MHD events**
  - **Transport in the presence of magnetic islands**
  - **Core-SOL interface** and . . .

• **Advanced technique** of computer science
  - **Parallel computing**: PC cluster, Scalar-Parallel, Vector-Parallel
  - **Distributed computing**: GRID computing, Globus, ITBL
Integrated Code Development Based on BPSI Framework

Integrated code: TASK and TOPICS

NIFS

Universities

JAEA

BPSI

TASK/3D

TASK

TOPICS

HINT MEGA

GNET GRM

OFMC MARG2D
TASK Code

- Transport Analysing System for TokamaK

- Features
  - Core of Integrated Modeling Code in BPSI
    - Modular structure
    - Reference data interface and standard data set
  - Various Heating and Current Drive Scheme
    - EC, LH, IC, AW, NB
  - High Portability
    - Most of library routines included (except LAPACK and MPI)
    - Own graphic libraries (X11, eps, OpenGL)
  - Development using CVS (Concurrent Version System)
    - Open Source (Pre-release with f77: http://bpsi.nucleng.kyoto-u.ac.jp/task/)
  - Parallel Processing using MPI Library
  - Extension to Toroidal Helical Plasmas
**Modules of TASK**

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<th>Description</th>
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<td><strong>TR</strong></td>
<td>1D Transport</td>
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<td><strong>WR</strong></td>
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<td>Libraries</td>
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**Under Development**

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
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<tr>
<td><strong>TX</strong></td>
<td>Transport analysis including plasma rotation and $E_r$</td>
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<tr>
<td><strong>WA</strong></td>
<td>Global linear stability analysis</td>
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<tr>
<td><strong>WI</strong></td>
<td>Integro-differential wave analysis (FLR, $k \cdot \nabla B \neq 0$)</td>
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</table>

All developed in Kyoto U
Modular Structure of TASK

Experimental Database
- ITPA Profile DB
  - $n(p), T(p), q(p), P_{abs}(p) \ldots$
- JT-80 Exp. Data
  - $n(p), T(p), q(p), P_{abs}(p) \ldots$
- Simulation DB
  - $n(p), T(p), q(p), P_{abs}(p) \ldots$

Data Interface
- PL
  - $p(\psi), q(\psi), u_{\psi}(\psi)$
  - $V'(p), P_{abs}(p), j_{CD}(p)$
  - $V'(p), n(p), V(p), T(p), E(p,\theta,\varphi)$
  - $\psi(R,Z)$
  - $\psi(R,Z)$
  - $n_T, T_B, f(p_{//}, p_{\perp})$

Applications:
- EQ: Equilibrium
- TR: Transport
- FP: Fokker-Planck
- WR: Ray Tracing
- WM: Full Wave
- DP: Wave Dispersion
Data Interface Layer PL

- **Role of Interface Layer**
  - To keep the present status of plasma
  - To store the history of plasma
  - Interface to file system
  - Interface to experimental profile database
  - Interface to simulation profile database

- **Data to be stored**
  - **Standard dataset**
    - Shot data, Device data
    - Equilibrium data, Metric data
    - Fluid plasma data, Kinetic plasma data
    - Dielectric tensor data, Full wave data, Ray/Beam tracing data
  - **User-defined data**
# Standard Dataset (interim)

## Shot data
- Machine ID, Shot ID, Model ID

## Device data: (Level 1)
- **RR**: \( R \) m, Geometrical major radius
- **RA**: \( a \) m, Geometrical minor radius
- **RB**: \( B \) m, Wall radius
- **BB**: \( B \) T, Vacuum toroidal mag. field
- **RKAP**: \( \kappa \), Elongation at boundary
- **RDLT**: \( \delta \), Triangularity at boundary
- **RIP**: \( I_p \) A, Typical plasma current

## Equilibrium data: (Level 1)
- **PSI2D**: \( \psi_p(R,Z) \) Tm\(^2\), 2D poloidal magnetic flux
- **PSIT**: \( \psi_t(\rho) \) Tm\(^2\), Poloidal magnetic flux
- **PSIP**: \( \psi_p(\rho) \) Tm\(^2\), Poloidal magnetic flux
- **PSSI**: \( p(\rho) \) MPa, Plasma pressure
- **TPSI**: \( T(\rho) \) Tm, \( B_0 R \)
- **QPSI**: \( 1/q(\rho) \), Safety factor

## Metric data
- **1D**: \( V'(\rho), \langle \nabla V \rangle(\rho), \cdots \)
- **2D**: \( g_{ij}, \cdots \)
- **3D**: \( g_{ij}, \cdots \)

## Fluid plasma data
- **NSMAX**: \( s \), Number of particle species
- **PA**: \( A_s \), Atomic mass
- **PZ0**: \( Z_{0s} \), Charge number
- **PZ**: \( Z_s \), Charge state number
- **PN**: \( n_s(\rho) \) m\(^3\), Number density
- **PT**: \( T_s(\rho) \) eV, Temperature
- **PU**: \( u_{s\phi}(\rho) \) m/s, Toroidal rotation velocity

## Kinetic plasma data
- **FP**: \( f(p, \theta_p, \rho) \), momentum dist. fn at \( \theta = 0 \)

## Dielectric tensor data
- **CEPS**: \( \mathbf{\epsilon}(\rho, \chi, \zeta) \), Local dielectric tensor

## Full wave field data
- **CE**: \( E(\rho, \chi, \zeta) \) V/m, Complex wave electric field
- **CB**: \( B(\rho, \chi, \zeta) \) Wb/m\(^2\), Complex wave magnetic field

## Ray/Beam tracing field data
- **RRAY**: \( R(\ell) \) m, \( R \) of ray at length \( \ell \)
- **ZRAY**: \( Z(\ell) \) m, \( Z \) of ray at length \( \ell \)
- **PRAY**: \( \phi(\ell) \) rad, \( \phi \) of ray at length \( \ell \)
- **CERAY**: \( E(\ell) \) V/m, Wave electric field at length \( \ell \)
- **PWRAY**: \( P(\ell) \) W, Wave power at length \( \ell \)
- **DRAY**: \( d(\ell) \) m, Beam radius at length \( \ell \)
- **VRAY**: \( v(\ell) \) 1/m, Beam curvature at length \( \ell \)
## Execution Control Interface in BPSI

### Example for TASK/TR

<table>
<thead>
<tr>
<th>TR_INIT</th>
<th>Initialization (Default value)</th>
<th>BPSX_INIT('TR')</th>
</tr>
</thead>
<tbody>
<tr>
<td>TR_PARM(ID,PSTR)</td>
<td>Parameter setup (Namelist input)</td>
<td>BPSX_PARM('TR',ID,PSTR)</td>
</tr>
<tr>
<td>TR_PROF(T)</td>
<td>Profile setup (Spatial profile, Time)</td>
<td>BPSX_PROF('TR',T)</td>
</tr>
<tr>
<td>TR_EXEC(DT)</td>
<td>Exec one step (Time step)</td>
<td>BPSX_EXEC('TR',DT)</td>
</tr>
<tr>
<td>TR_GOUT(PSTR)</td>
<td>Plot data (Plot command)</td>
<td>BPSX_GOUT('TR',PSTR)</td>
</tr>
<tr>
<td>TR_SAVE</td>
<td>Save data in file</td>
<td>BPSX_SAVE('TR')</td>
</tr>
<tr>
<td>TR_LOAD</td>
<td>load data from file</td>
<td>BPSX_LOAD('TR')</td>
</tr>
<tr>
<td>TR_TERM</td>
<td>Termination</td>
<td>BPSX_TERM('TR')</td>
</tr>
</tbody>
</table>

### Module registration

- `TR_STRUCT%INIT=TR_INIT`
- `TR_STRUCT%PARM=TR_PARM`
- `TR_STRUCT%EXEC=TR_EXEC`
- ...`
- BPSX_REGISTER('TR',TR_STRUCT)
Full wave analysis: TASK/WM

- **magnetic surface coordinate**: \((\psi, \theta, \varphi)\)
- Boundary-value problem of **Maxwell’s equation**

\[
\nabla \times \nabla \times \mathbf{E} = \frac{\omega^2}{c^2} \varepsilon \cdot \mathbf{E} + i \omega \mu_0 \mathbf{j}_{\text{ext}}
\]

- Kinetic **dielectric tensor**: \(\varepsilon\)
  - Wave-particle resonance: \(Z[(\omega - n\omega_c)/k_{||}v_{\text{th}}]\)
  - Fast ion: Drift-kinetic

\[
\left[ \frac{\partial}{\partial t} + v_{||} \nabla_{||} + (v_d + v_E) \cdot \nabla + \frac{e\alpha}{m\alpha} (v_{||}E_{||} + v_d \cdot E) \frac{\partial}{\partial \varepsilon} \right] f_{\alpha} = 0
\]

- Poloidal and toroidal **mode expansion**
  - Accurate estimation of \(k_{||}\)

- Eigenmode analysis: **Complex eigen frequency** which maximize wave amplitude for fixed excitation proportional to electron density
ICRF Waves in Toroidal Helical Plasmas
(Cold Plasma Model)

**LHD** \((B_0 = 3 \text{ T}, R_0 = 3.8 \text{ m})\)

\[ f = 42 \text{ MHz}, \; n_{\phi 0} = 20, \; n_{e0} = 3 \times 10^{19} \text{ m}^{-3}, \; n_H/(n_{\text{He}} + n_H) = 0.235, \]

\[ N_{r\text{max}} = 100, \; N_{\theta\text{max}} = 16 \; (m = -7 \ldots 7), \; N_{\phi\text{max}} = 4 \; (n = 10, 20, 30) \]

Wave electric field (imaginary part of poloidal component)

Power deposition profile (minority ion)
Fokker-Planck Analysis : TASK/FP

- **Fokker-Planck equation**
  
  for **velocity distribution function** \( f(p_{||}, p_{\perp}, \psi, t) \)
  
  \[
  \frac{\partial f}{\partial t} = E(f) + C(f) + Q(f) + L(f)
  \]
  
  - \( E(f) \): Acceleration term due to DC electric field
  - \( C(f) \): Coulomb collision term
  - \( Q(f) \): Quasi-linear term due to wave-particle resonance
  - \( L(f) \): Spatial diffusion term

- **Bounce-averaged**: Trapped particle effect, zero banana width
- **Relativistic**: momentum \( p \), weakly relativistic collision term
- **Nonlinear collision**: momentum or energy conservation
- **Three-dimensional**: spatial diffusion (neoclassical, turbulent)
Wave Dispersion Analysis : TASK/DP

- **Various Models of Dielectric Tensor** $\hat{\varepsilon}(\omega, k; r)$:
  - Resistive MHD model
  - Collisional cold plasma model
  - Collisional warm plasma model
  - Kinetic plasma model (Maxwellian, non-relativistic)
  - Kinetic plasma model (Arbitrary $f(v)$, relativistic)
  - Gyro-kinetic plasma model (Maxwellian)
  - Gyro-kinetic plasma model (Arbitrary $f(v)$, non-relativistic)

- **Arbitrary $f(v)$**:
  - Relativistic Maxwellian
  - Output of TASK/FP
Self-Consistent Wave Analysis with Modified $f(v)$

- **Modification of velocity distribution from Maxwellian**
  - Absorption of ICRF waves in the presence of energetic ions
  - Current drive efficiency of LHCD
  - NTM controllability of ECCD (absorption width)

- **Self-consistent wave analysis including modification of $f(v)$**
Development of Self-Consistent Wave Analysis

- **Code Development in TASK**
  - Ray tracing analysis with arbitrary $f(v)$: **Already done**
  - Full wave analysis with arbitrary $f(v)$: **Completed**
  - Fokker-Plank analysis of ray tracing results: **Already done**
  - Fokker-Plank analysis of full wave results: **Almost competed**
  - Self-consistent iterative analysis: **Preliminary**

- **Tail formation by ICRF minority heating**

Momentum Distribution  Tail Formation  Power deposition
Diffusive Transport Analysis: TASK/TR

- **Transport Equation Based on Gradient-Flux Relation**
  - **Multi thermal species**: e.g. Electron, D, T, He
    - Density, thermal energy, (toroidal rotation)
  - **Two beam components**: Beam ion, Energetic $\alpha$
    - Density, toroidal rotation
  - **Neutral**: Two component (cold and hot), Diffusion equation
  - **Impurity**: Thermal species or fixed profile

- **Transport Model**
  - **Neoclassical**: Wilson, Hinton & Hazeltine, Sauter, NCLASS
  - **Turbulent**: CDBM (current diffusive ballooning mode), GLF23 (V1.61), IFS/PPPL, Weiland

- **Interface to Experimental Data**
  - **UFILE** (ITPA profile DB)
CDBM Transport Model: CDBM05

- **Thermal Diffusivity** (Marginal: $\gamma = 0$)
  \[
  \chi_{TB} = F(s, \alpha, \kappa, \omega_{E1}) \alpha^{3/2} \frac{c^2}{\omega_{pe}^2} \frac{v_A}{qR}
  \]

  - Magnetic shear
    \[
    s \equiv \frac{r}{q} \frac{dq}{dr}
    \]
  - Pressure gradient
    \[
    \alpha \equiv -q^2 R \frac{d\beta}{dr}
    \]
  - Elongation
    \[
    \kappa \equiv \frac{b}{a}
    \]
  - $E \times B$ rotation shear
    \[
    \omega_{E1} \equiv \frac{r^2}{sv_A} \frac{d}{dr} \frac{E}{rrB}
    \]

- Weak and negative magnetic shear, Shafranov shift, elongation, and $E \times B$ rotation shear reduce thermal diffusivity.

\[
F(s, \alpha, \kappa, \omega_{E1}) = \left( \frac{2\kappa^{1/2}}{1 + \kappa^2} \right)^{3/2}
\]

\[
\begin{align*}
1 & \quad 1 \\
1 + G_1 \omega_{E1}^2 & \quad \sqrt{2(1 - 2s')}(1 - 2s' + 3s'^2) \\
1 + 9 \sqrt{2}s'^{5/2} & \quad \sqrt{2}(1 - 2s' + 3s'^2 + 2s'^3)
\end{align*}
\]

\[
\begin{align*}
\text{for } s' = s - \alpha < 0 \\
\text{for } s' = s - \alpha > 0
\end{align*}
\]
Comparison of Transport Models: ITPA Profile DB

Deviation of Stored Energy

CDBM

CDBM05

GLF23

Weiland
TFTR #88615 (L-mode, NBI heating)

CDBM  CDBM05  GLF23  Weiland

Common Profiles
DIII-D #78316 (L-mode, ECH and ICH heatings)

**CDBM**

- $T_e$ [keV]
- $\chi_e$ [m$^2$/s] (Top row)
- $T_i$ [keV] (Middle row)
- $\chi_i$ [m$^2$/s] (Bottom row)

**CDBM05**

- $T_e$ [keV]
- $\chi_e$ [m$^2$/s] (Top row)
- $T_i$ [keV] (Middle row)
- $\chi_i$ [m$^2$/s] (Bottom row)

**GLF23**

- $T_e$ [keV]
- $\chi_e$ [m$^2$/s] (Top row)
- $T_i$ [keV] (Middle row)
- $\chi_i$ [m$^2$/s] (Bottom row)

**Weiland**

- $T_e$ [keV]
- $\chi_e$ [m$^2$/s] (Top row)
- $T_i$ [keV] (Middle row)
- $\chi_i$ [m$^2$/s] (Bottom row)

**Common Profiles**

- $n_e$ [10$^19$/m$^3$]
- $J_{\text{eff}}$ [MA/m$^2$] (Top row)
- $q$ (Middle row)
- $P_{\text{EC}}$ [MW/m$^3$] (Bottom row)
1D Transport code: TASK/TX

- **Dynamic Transport Equation**: *Fukuyama et al. PPCF (1994)*
  - Two fluid equation for electrons and ions
    - Flux surface averaged
    - Coupled with Maxwell equation
    - Neutral diffusion equation
  - Neoclassical transport
  - Turbulent transport
    - Current diffusive ballooning mode
    - Ambipolar diffusion through poloidal momentum transfer
    - Thermal diffusivity, Perpendicular viscosity
  - Maxwell’s equation, Poisson’s equation
  - Slowdown equation for beam component
  - Diffusion equation for neutral particles
Model Equation (1)

- **Fluid equations** (electrons and ions)

$$\frac{\partial n_s}{\partial t} = -\frac{1}{r} \frac{\partial}{\partial r} (rn_s u_{sr}) + S_s$$

$$\frac{\partial}{\partial t} (m_s n_s u_{sr}) = -\frac{1}{r} \frac{\partial}{\partial r} \left( rm_s n_s u_{sr}^2 \right) + \frac{1}{r} m_s n_s u_{s\theta}^2 + e_s n_s (E_r + u_{s\theta} B_{\phi} - u_s B_{\theta}) - \frac{\partial}{\partial r} n_s T_s$$

$$\frac{\partial}{\partial t} (m_s n_s u_{s\theta}) = -\frac{1}{r^2} \frac{\partial}{\partial r} \left( r^2 m_s n_s u_{sr} u_{s\theta} \right) + e_s n_s (E_{\theta} - u_{sr} B_{\phi}) + \frac{1}{r^2} \frac{\partial}{\partial r} \left( r^3 n_s m_s \mu_s \frac{\partial}{\partial r} \frac{u_{s\theta}}{r} \right)$$

$$+ F_{s\theta}^{NC} + F_{s\theta}^C + F_{s\theta}^W + F_{s\theta}^X + F_{s\theta}^L$$

$$\frac{\partial}{\partial t} (m_s n_s u_{s\phi}) = -\frac{1}{r} \frac{\partial}{\partial r} \left( rm_s n_s u_{sr} u_{s\phi} \right) + e_s n_s (E_{\phi} + u_{sr} B_{\theta}) + \frac{1}{r} \frac{\partial}{\partial r} \left( r n_s m_s \mu_s \frac{\partial}{\partial r} u_{s\phi} \right)$$

$$+ F_{s\phi}^C + F_{s\phi}^W + F_{s\phi}^X + F_{s\phi}^L$$

$$\frac{\partial}{\partial t} \frac{3}{2} n_s T_s = -\frac{1}{r \frac{\partial}{\partial r} \left( \frac{5}{2} u_{sr} n_s T_s - n_s \chi_s \frac{\partial}{\partial r} T_e \right) + e_s n_s (E_{\theta} u_{s\theta} + E_{\phi} u_{s\phi})$$

$$+ P_s^C + P_s^L + P_s^H$$
Model Equation (2)

- **Diffusion equation for (fast and slow) neutral particles**

\[
\frac{\partial n_0}{\partial t} = -\frac{1}{r} \frac{\partial}{\partial r} \left( -rD_0 \frac{\partial n_0}{\partial r} \right) + S_0
\]

- **Maxwell’s equation**

\[
\frac{1}{r} \frac{\partial}{\partial r} (rE_r) = \frac{1}{\varepsilon_0} \sum_s e_s n_s
\]

\[
\frac{\partial B_{\theta}}{\partial t} = \frac{\partial E_\phi}{\partial r}, \quad \frac{\partial B_\phi}{\partial t} = -\frac{1}{r} \frac{\partial}{\partial r} (rE_\phi)
\]

\[
\frac{1}{c^2} \frac{\partial E_\theta}{\partial t} = -\frac{\partial}{\partial r} B_\phi - \mu_0 \sum_s e_s n_s u_{s\theta}, \quad \frac{1}{c^2} \frac{\partial E_\phi}{\partial t} = \frac{1}{r} \frac{\partial}{\partial r} (rB_\theta) - \mu_0 \sum_s e_s n_s u_{s\phi}
\]
Neoclassical Transport Model

- **Neoclassical transport**
  - Viscosity force arises when plasma rotates in the poloidal direction.
  - Banana-Plateau regime

\[ F_{s\theta}^{NC} = - \sqrt{\pi q^2 n_s m_s} \frac{v_{Ts}}{qR} \frac{v_s^*}{1 + v_s^*} u_{s\theta} \]

\[ v_s^* \equiv \frac{v_s q R}{\varepsilon^{3/2} v_{Ts}} \]

- **This poloidal viscosity force induces**
  - Neoclassical radial diffusion
  - Neoclassical resistivity
  - Bootstrap current
  - Ware pinch
Simulation of plasma rotation and radial electric field

- **JFT-2M parameter**: NBI co-injection $\rightarrow$ counter-injection
- Toroidal rotation $\Rightarrow$ Negative $E_r$ $\Rightarrow$ Density peaking
- **TASK/TX**: Particle Diffusivity: 0.3 m$^2$/s, Ion viscosity: 10 m$^2$/s
Transport Modeling in Helical Plasma

- Neoclassical toroidal viscosity
- Negative magnetic shear
- Preliminary Result
  - **NBI heating** \((P = 5 \text{ MW})\) : Order of magnitude slower rotation
Future Plan of TASK code

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<th>Category</th>
<th>Present Status</th>
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<th>In 5 years</th>
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<td>Fixed/Free Boundary</td>
<td>Equilibrium Evolution</td>
<td>Start Up Analysis</td>
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<td><strong>Core Transport</strong></td>
<td>1D Diffusive TR</td>
<td>Kinetic TR</td>
<td>2D Fluid TR</td>
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<td>1D Dynamic TR</td>
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<td><strong>SOL Transport</strong></td>
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<td>2D Fluid TR</td>
<td>Plasma-Wall Interaction</td>
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<tr>
<td><strong>Neutral Transport</strong></td>
<td>1D Diffusive TR</td>
<td>Orbit Following</td>
<td></td>
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<tr>
<td><strong>Energetic Ions</strong></td>
<td>Kinetic Evolution</td>
<td>Orbit Following</td>
<td></td>
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<tr>
<td><strong>Wave Beam</strong></td>
<td>Ray/Beam Tracing</td>
<td>Beam Propagation</td>
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<tr>
<td><strong>Full Wave</strong></td>
<td>Kinetic ε</td>
<td>Gyro Integral ε</td>
<td>Orbit Integral ε</td>
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<tr>
<td><strong>Stabilities</strong></td>
<td>Sawtooth Osc.</td>
<td>Tearing Mode</td>
<td>Systematic Stability Analysis</td>
</tr>
<tr>
<td></td>
<td>ELM Model</td>
<td>Resistive Wall Mode</td>
<td></td>
</tr>
<tr>
<td><strong>Turbulent Transport</strong></td>
<td>CDBM Model</td>
<td>Linear GK + ZF</td>
<td>Nonlinear ZK + ZF</td>
</tr>
</tbody>
</table>

- Systematic Stability Analysis
- Start Up Analysis
- Nonlinear ZK + ZF
Extension to TASK/3D

• **3D Equilibrium:**
  ◦ Interface to equilibrium data from VMEC or HINT

• **Modules 3D-ready:**
  ◦ **WR**: Ray and beam tracing
  ◦ **WM**: Full wave analysis

• **Modules to be updated:**
  ◦ **TR**: Diffusive transport (with an appropriate model of $E_r$)
  ◦ **TX**: Dynamical transport (with neoclassical toroidal viscosity)
  ◦ **FP**: Fokker-Planck analysis (with helical ripple trapping)

• **Modules to be added:**
  ◦ **EI**: Time evolution of current profile in helical geometry
Summary

• We are developing **TASK** code as a reference core code for burning plasma simulation based on transport analysis.

• **Standard dataset** and **module interface** are being implemented.

• Preliminary results of **self-consistent analysis of wave heating and current drive** describing the time evolution of the momentum distribution function and its influence on the wave propagation and absorption have been obtained.

• **Extension to 3D configuration** is on-going in collaboration with Dr. Y. Nakamura and NIFS.  
  (See Next Presentation)
Access to TASK code

- **Required Environment**
  - Unix-like OS (Linux, Mac OSX, · · ·)
  - X-window system
  - Fortran95 compiler (gfortran, g95, ifort, pgf95, xlf95, sxf90, · · ·)

- **Source code**
  - **Stable version**: Web site (http://bpsi.nucleng.kyoto-u.ac.jp/task/)
  - **Latest version**: CVS tree (Read only) [password required]
  - **Developer**: CVS tree (R/W) [account required]

- **User support**
  - Uniform user interface
  - English guidebook in preparation: by the end of 2006