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Code Interface Development Activities in Japan

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in collaboration with

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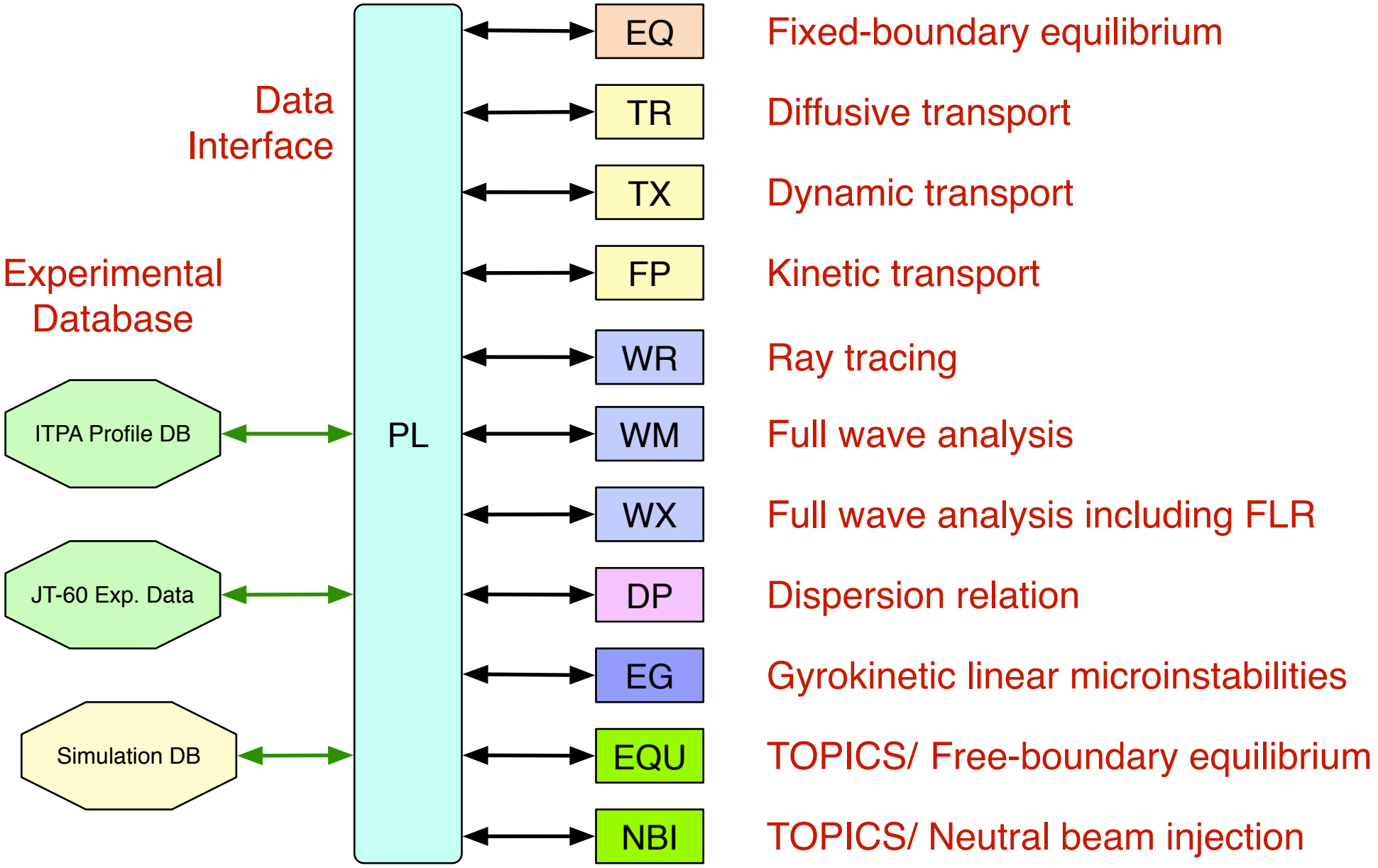
Structure of TASK



Inter-Module Collaboration Interface: TASK/PL

- **Role of Module Interface**
  - **Data exchange between modules**:
    - **Standard dataset**: Specify set of data (cf. ITPA profile DB)
    - **Specification of data exchange interface**: initialize, set, get
  - **Execution control**:
    - **Specification of execution control interface**: initialize, setup, exec, visualize, terminate
    - **Uniform user interface**: parameter input, graphic output
- **Role of data exchange interface: TASK/PL**
  - **Keep present status of plasma and device**
  - **Store history of plasma**
  - **Save into file and load from file**
  - **Interface to experimental data base**

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	κ		Elongation at boundary
RDLT	δ		Triangularity at boundary
RIP	I_p	A	Typical plasma current

Equilibrium data: (Level 1)

PSI2D	$\psi_\mathrm{p}(R,Z)$	Tm^2	2D poloidal magnetic flux
PSIT	$\psi_\mathrm{t}(\rho)$	Tm^2	Toroidal magnetic flux
PSIP	$\psi_\mathrm{p}(\rho)$	Tm^2	Poloidal magnetic flux
ITPSI	$I_\mathrm{t}(\rho)$	Tm	Poloidal current: $2\pi B_\phi R$
IPPSI	$I_\mathrm{p}(\rho)$	Tm	Toroidal current
PPSI	$p(\rho)$	MPa	Plasma pressure
QINV	$1/q(\rho)$		Inverse of 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
QINV	$1/q(\rho)$		Inverse of safety factor

Kinetic plasma data

FP	$f(p,\theta_p,\rho)$	momentum dist. fn at $\theta = 0$

Dielectric tensor data

CEPS	$\overleftrightarrow{\epsilon}(\rho,\chi,\zeta)$	Local dielectric tensor

Full wave field data

CE	$\boldsymbol{E}(\rho,\chi,\zeta)$	V/m	Complex wave electric field
CB	$\boldsymbol{B}(\rho,\chi,\zeta)$	$\mathrm{Wb/m}^2$	Complex wave magnetic field

Ray/Beam tracing field data

RRAY	$R(\ell)$	m	R of ray at length ℓ
ZRAY	$Z(\ell)$	m	Z of ray at length ℓ
PRAY	$\phi(\ell)$	rad	ϕ of ray at length ℓ
CERAY	$\boldsymbol{E}(\ell)$	V/m	Wave electric field at length ℓ
PWRAY	$\boldsymbol{P}(\ell)$	W	Wave power at length ℓ
DRAY	$\boldsymbol{d}(\ell)$	m	Beam radius at length ℓ
VRAY	$\boldsymbol{v}(\ell)$	1/m	Beam curvature at length ℓ

Data Exchange Interface

- **Data structure**: **Derived type** (Fortran95): structured type

e.g.

time	`plasmaf%time`
number of grid	`plasmaf%nrmax`
square of grid radius	`plasmaf%s(nr)`
plasma density	`plasmaf%data(nr)%pn`
plasma temperature	`plasmaf%data(nr)%pt`

- **Program interface**

e.g.

Set data	`bpsd_set_data(plasmaf,ierr)`
Get data	`bpsd_get_data(plasmaf,ierr)`

- **Other functions**:
  - Save data into a file, Load data from a file, Plot data

Execution Control Interface

- **Example for TASK/TR**

`TR_INIT`	Initialization (Default value)	`BPSX_INIT('TR')`
`TR_PARM(ID,PSTR)`	Parameter setup (Namelist input)	`BPSX_PARM('TR',ID,PSTR)`
`TR_SETUP(T)`	Profile setup (Spatial profile, Time)	`BPSX_SETUP('TR',T)`
`TR_EXEC(DT)`	Exec one step (Time step)	`BPSX_EXEC('TR',DT)`
`TR_GOUT(PSTR)`	Plot data (Plot command)	`BPSX_GOUT('TR',PSTR)`
`TR_SAVE`	Save data in file	`BPSX_SAVE('TR')`
`TR_LOAD`	load data from file	`BPSX_LOAD('TR')`
`TR_TERM`	Termination	`BPSX_TERM('TR')`

- **Module registration**

```
TR_STRUCT%INIT=TR_INIT
TR_STRUCT%PARM=TR_PARM
TR_STRUCT%EXEC=TR_EXEC
  ...
BPSX_REGISTER('TR',TR_STRUCT)
```

Example of data structure: plasmaf

```
type bpsd_plasmaf_data
   real(8) :: pn      ! Number density [m^-3]
   real(8) :: pt      ! Temperature [eV]
   real(8) :: ptpr    ! Parallel temperature [eV]
   real(8) :: ptpp    ! Perpendicular temperature [eV]
   real(8) :: pu      ! Parallel flow velocity [m/s]
end type bpsd_plasmaf_data
type bpsd_plasmaf_type
   real(8) :: time
   integer :: nrmax      ! Number of radial points
   integer :: nsmax      ! Number of particle species
   real(8), dimension(:), allocatable :: s
                         ! (rho^2) : normarized toroidal flux
   real(8), dimension(:), allocatable :: qinv
                         ! 1/q : inverse of safety factor
   type(bpsd_plasmaf_data), dimension(:,:), allocatable :: data
end type bpsd_plasmaf_type
```

Examples of sequence in a module

- **TR_EXEC(dt)**

```
call bpsd_get_data(plasmaf,ierr)
call bpsd_get_data(metric1D,ierr)
local data <- plasmaf,metric1D
advance time step dt
plasmaf <- local data
call bpsd_set_data(plasmaf,ierr)
```

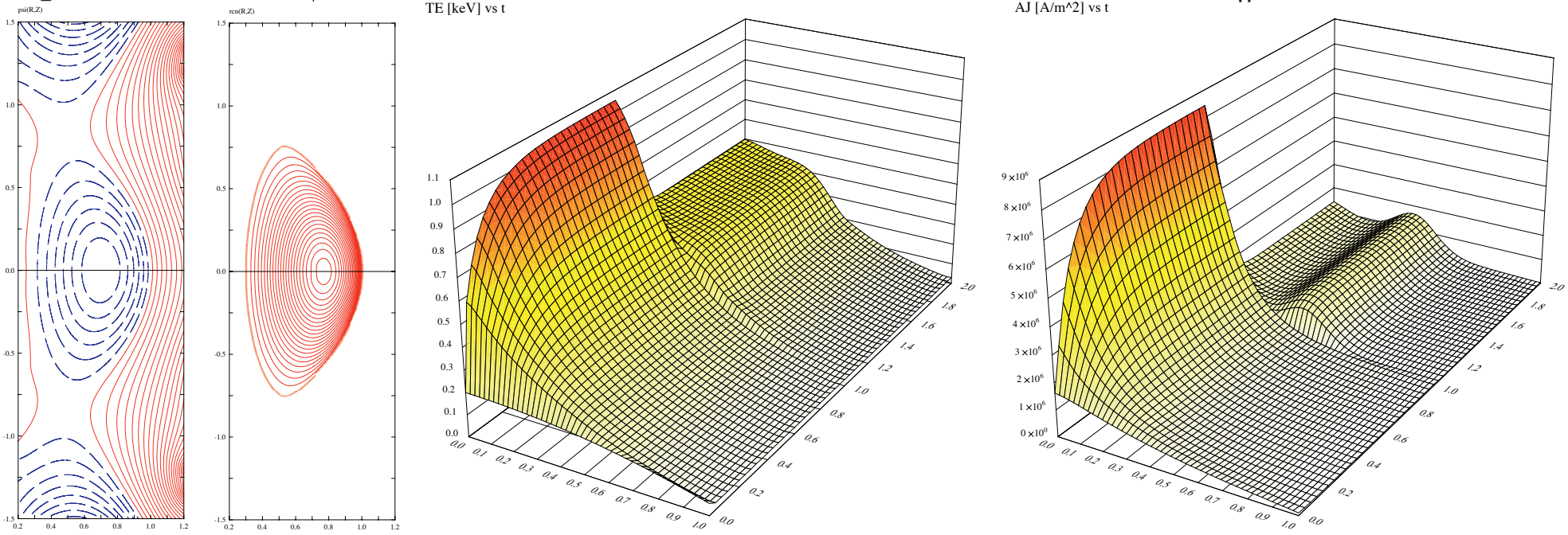
- **EQ_CALC**

```
call bpsd_get_data(plasmaf,ierr)
local data <- plasmaf
calculate equilibrium
update plasmaf
call bpsd_set_data(plasmaf,ierr)
equ1D,metric1D <- local data
call bpsd_set_data(equ1D,ierr)
call bpsd_set_data(metric1D,ierr)
```

Example: Coupling of TASK/TR and TOPICS/EQU

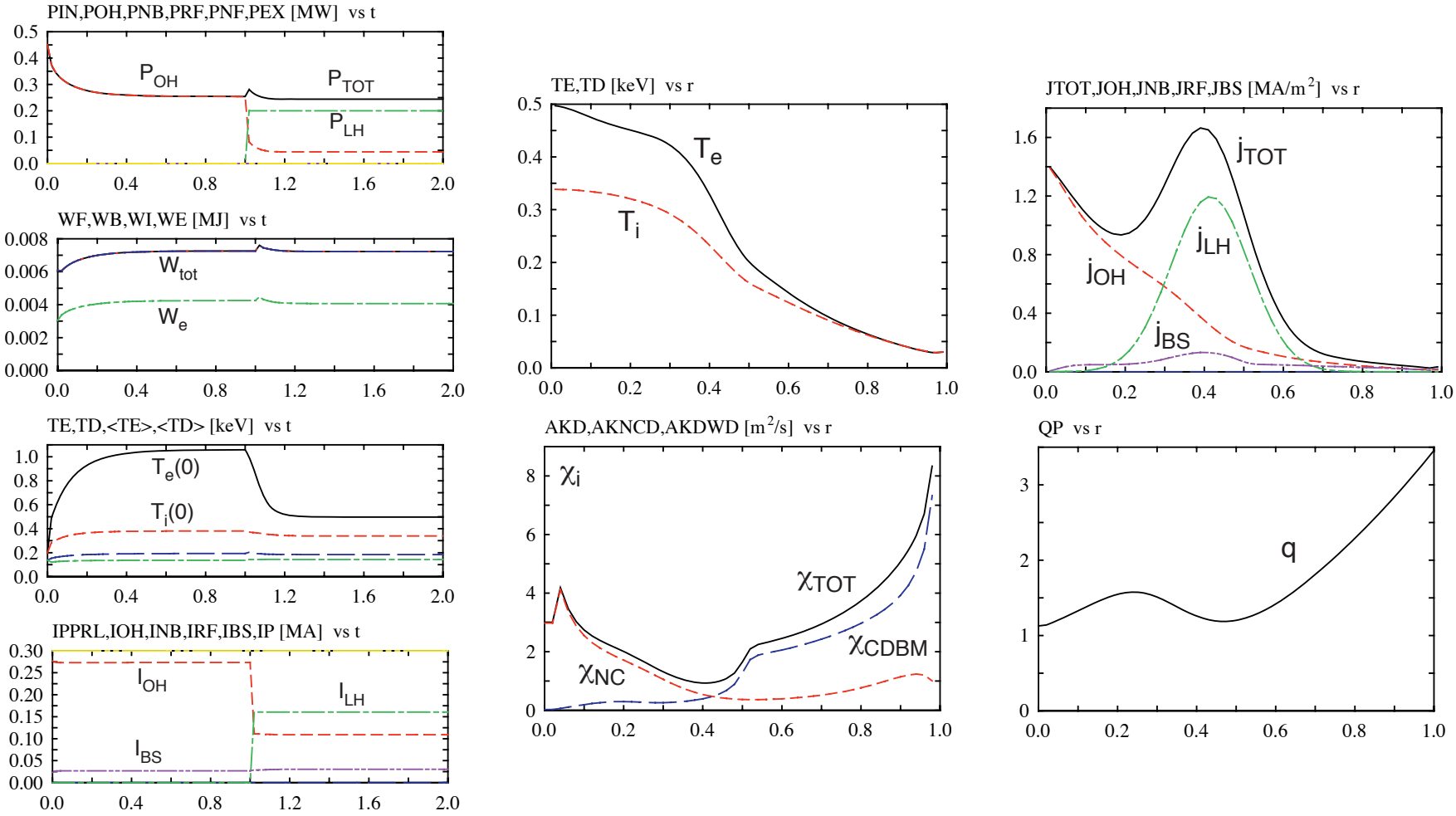
- **TOPICS/EQU**: Free boundary 2D equilibrium
- **TASK/TR** Diffusive 1D transport (CDBM + Neoclassical)
- **QUEST** parameters:
  - $R = 0.64\,\mathrm{m},\ a = 036\,\mathrm{m},\ B = 0.64\,\mathrm{T},\ I_\mathrm{p} = 300\,\mathrm{kA}$, OH+LHCD

$\psi_\mathrm{p}(R,Z)$ j_ϕ $T_\mathrm{e}(\rho,t)$ $j_{||}(\rho,t)$



Transport simulation

- **OH + off-axis LHCD**: 200 kW
- **Formation of internal transport barrier** (equilibrium not solved)



Summary

- We have developed a part of **standard dataset, data exchange interface and execution control** and implemented them in TASK code. An example of coupling between TOPICS/EQU and TASK/TR was shown, though not yet completed. Some other modules of TOPICS will be incorporated soon.

- We are going to develop **a minimal set of variables** to describe the plasma state, not a complete set of variables initially. We have an interface for **user-defined variables**. The set of variables will be increased gradually based on experiences on the modules.