Confinement Database and Modeling Topical Group

W.A. Houlberg
for the CDBM Topical Group

ITPA Coordinating Committee Meeting
24-25 October 2002
IPP-Garching, Germany

Outline

Guidance for CDBM effort:

- **Scope, High Priority, Medium Term and Long Term Research Topics**

Responses to CC Action List from last meeting:

- **List of databases, Shared Profile Database, Coordination Issues**

Recommendations for International Collaboration

Publications

Meetings:

- **2002, 2003**

New initiatives from the Cadarache meeting:

- **Revisiting Global L-mode Confinement**
- **Validating predictive transport codes**

Scope of the ITPA CDBM Topical Group

The objective of the ITPA TG on Confinement Databases and Modelling is to establish a stronger basis for predicting the confinement of Burning Plasma Experiments (BPXs) in collaboration with the other ITPA TGs. The long-term goal is the validation of fully predictive models for particle, momentum, energy, and current transport. In pursuit of our objectives and goals, the scope of activity for the TG on Confinement Databases and Modelling will entail assembly of multi-machine databases for global and profile analyses, development of associated tools for using those databases, testing physics models against the data, and providing projections for BPXs using the best available models.

High Priority Research Topics

- **Assemble and manage multi-machine databases, analysis tools, and physics models. These include:**
  - **Global L-mode and Global H-mode Confinement databases**
  - **H-mode Threshold database**
  - **Joint Pedestal/H-mode database**
  - **Profile databases**
- **Evaluate global and local models for plasma confinement by testing against the databases. For example:**
  - **Global models may take into account profile effects, pedestal parameters, and non-linear dependencies to identify physical reasons for machine-to-machine differences**
  - **1-D models may include the additional of shear damping and more complete geometry in transport models, and improved particle, momentum, current and energy sources.**
- **Use the models to predict the performance of Burning Plasma Experiments, including an estimate of the uncertainty of the predictions.**

Medium Term Research Topics

Test models for density profile evolution including the influences of gas fuelling and pellet injection (with ablation drift effects) on confinement, density limits, and impurity evolution.

Test models for plasma poloidal and toroidal rotation and their influence on confinement.

Test improved models for electron transport.

Long Term Research Topics

Test models for the effects of Alfvén eigenmodes, neoclassical tearing modes and other kinetic and MHD modes that also may influence confinement more strongly in BPXs than in present experimental devices.

Integrate the models to identify operating scenarios that explore the complex interaction between physics elements of burning plasmas, and to provide the basis for interpreting their behaviour.

Responses to CC Action List of 18 April 2002

List of databases, functionality, managers, locations, Working Groups

Database:	**International Global H-mode Confinement Database**
Functionality:	**Analysis of global confinement in H–mode plasmas**
Manager:	**K. Thomsen, EFDA CSU, thomsek@ipp.mpg.de**
Location/website:	**IPP Garching, http://pc-sql-server.ipp.mpg.de/igd/**
Working Group:	**26 members**
Database:	**International Global L-mode Confinement Database**
Functionality:	**Analysis of global confinement in L–mode plasmas**
Manager:	**O.J.W.F. Kardaun, IPP Garching, ojk@ipp.mpg.de**
Location/website:	**IPP Garching, http://pc-sql-server.ipp.mpg.de/igd/**
Working Group:	**26 members**
Database:	**International H-mode Power Threshold Database**
Functionality:	**Analysis of the L-H and H-L transition thresholds**
Manager:	**F. Ryter, IPP Garching, ryter@ipp.mpg.de**
Location/website:	**IPP Garching, http://pc-sql-server.ipp.mpg.de/igd/**
Working Group:	**25 members**
Database:	**International Profile Database**
Functionality:	**Analysis of local transport and model testing**
Manager:	**C. Roach, UKAEA Culham, colin.m.roach@ukaea.org.uk**
Location/website:	**UKAEA Culham, http://tokamak-profiledb.ukaea.org.uk/**
Working Group:	**19 members**

Responses to CC Action List of 18 April 2002

Proposal for a Shared Profile Database

To be reported separately at this meeting:

- **An 'Oversight Group' should be established by relevant TGs for the Profile Database (Chair: W. Houlberg)**
- **The Group should establish protocols for type and format of data to be submitted**
- **It should also recommend how to best develop the necessary tools for managing and accessing the database**
- **Report to the next meeting of the ITPA CC**

Responses to CC Action List of 18 April 2002

Coordination Issues

Distribution of responsibilities for 'internal transport barriers,' 'improved scenarios,' etc needs to be clarified

TG Chairs/Co-Chairs to identify areas where interfaces exist with other TGs and nominate 'responsible officers' to ensure coordination in such areas

Actions:

- **Two combined sessions were held between the Modeling group of the CDBM TG and Transport/ITB TG at Cadarache:**
  - **Transport and ITB TG will take lead responsibility, supported by modelers**
  - **CDBM will take responsibility for benchmarking models (MMM, B/GB, Weiland, GLF23, …) in predictive codes (TRANSP, JETTO, Corsica, …)**
- **A combined session was held between the Modeling group of the CDBM TG and the Steady-State and Energetic Particles TG at Cadarache**
  - **SS/EP TG will identify candidate discharges from various devices to add to the Profile DB**
  - **CDBM will take responsibility for applying predictive codes and models to these cases**

Recommendations for International Collaboration

- **Pellet injection with inside and vertical launch is ripe for a coordinated attack on fueling issues:**
  - **ASDEX-UG, DIII-D, FTU, JET, JT-60U, MAST, TEXTOR, and TS have capabilities and/or plans for adding different launch positions**
  - **New diagnostics have recently been added or planned**
  - **Many bi-lateral collaborations are in existence on pellets**
  - **All can contribute to a database to examine the ablatant drift effect**
  - **ASDEX-UG, DIII-D, JET, JT-60U can contribute to examining the particle and energy loss associated with ELMs that are triggered by pellets**
- **More data is needed with different isotopes on the same machine:**
  - **Present isotope data is correlated with machines and may be masking other scaling**
- **Confinement scaling experiments with β need to be extended over a broader range of ρ_* and ν_***
- **More pedestal data is needed:**
  - **Scaling experiments**
  - **Expand databases for core + pedestal global analysis**

Publications

IAEA 2002 Lyon:

- **J. Snipes, et al, "Multi-Machine Global Confinement and H-mode Threshold Analysis," CT/P-04**

  The latest prediction from 7 tokamaks with ITER similar configurations for the threshold power required in deuterium plasmas in ITER with a 2 standard deviation uncertainty interval of 28 to 71 MW. This is somewhat lower than the previous 6 tokamak scaling, which gave a point prediction of 52 MW and a 2 standard deviation uncertainty interval of 34 – 80 MW because of the additional TCV data. Similarly, the predicted thresholds in FIRE and Ignitor are 24 MW and 17 MW, respectively. Low $q_{95} < 3$ and high $Z_{eff} > 2$ also lead to higher threshold power.

- **J.G. Cordey, et al, "A Two Term Model of the Confinement in ELMy H-modes Using the Global Confinement and Pedestal Databases," CT/P-02**

  The data in the joint-pedestal database has been fitted to two different types of models, the thermal conduction and MHD limit models. The two models give rise to a prediction for the pedestal stored energy in next step devices varying from 25% to 50% of the total stored energy. This uncertainty in the scaling of the pedestal is due to the condition of the pedestal database. Using these pedestal models, three two term models have been developed which give a good fit to the ELMy H-mode database DB3v11. All three models give confinement time predictions for both ITER and FIRE which are close to those of the one term model.

- **V. Mukhovatov, et al, "Comparison of ITER Performance Predicted by Semi-Empirical and Theory-Based Transport Models," CT/P-03**

Meetings Held in 2002

Spring 2002:

- **11-14 March (Mon-Thur), PPPL, Princeton, NJ**
- **Plus sessions on databases and analyses with Pedestal and ITB Groups**

Fall 2002:

- **21-23 October (Mon-Wed), Cadarache, France**
- **Joint with SS and ITB TGs**

Meetings Proposed for 2003

Propose for Spring 2003:

- **8-11 April (Tues-Fri), Ioffe Institute, St. Petersburg, Russia**
- **Joint with ITB TG**

Possible for Fall 2003:

- **September following 9th H-mode Workshop, GA, San Diego, CA**
- **Probably joint with Pedestal TG**

Revisiting Global L-Mode Confinement

Reasons for reactivation of database and analysis:

- More accurately predict hydrogen L-mode in ITER (first 5 years)
- Empirical benchmark for theories and next step BPXs

Time schedule:

- Jan 2003 - additional data
  - T-10 and MAST for aspect ratio
  - C-MOD and FTU for high density
  - JET for hydrogen
  - AUG, (DIII-D), JFT-2M for ITER-like shape
  - New data from other devices
- Mar 2003 - analysis

Validating Predictive Transport Codes

- **Benchmarking interpretive transport codes (all sources read from the PDB) in the earlier model testing was productive in uncovering differences in:**
  - **Reading and interpolating data from the PDB**
  - **Implementing highly non-linear and stiff transport models**
- **A set of predictive codes (TRANSP, JETTO, CORSICA, BALDUR, ASTRA, ONETWO, …) that have been used extensively in analysis mode now employ some of the more successful/popular transport models (B/GB, GLF23, MMM, Weiland, …)**
- **These are ready for:**
  - **Benchmarking transport and source models between codes**
  - **Validating models against experimental data**
  - **Generating more complete predictions for burning plasmas**
- **Application of some of these to a series of high confinement JET cases has:**
  - **Uncovered discrepancies in the NBI heating profiles, indicating possible differences in treatment of beam geometry, orbits, and ionization cross-sections**
- **A more complete set of high performance plasmas are being selected for:**
  - **Reading data for the predictive codes from the IPDB using MDSplus**
  - **Code benchmarking**
  - **Testing confinement models against best performance cases**
  - **Establishing a basis for better predictions of high performance conditions**