3rd International Conference on Frontiers of Plasma Physics and Technology

Summary

E. Lazzaro

Objectives

The objectives of this conference is to promote discussions, spread scientific information and exchange results on specific topics.

The variety of the subjects and the inter-disciplinary aspects have made the meeting very interesting and instructive for all the participants.

I will focus on 2 main group of topics:

- Physics of magnetically confined fusion plasmas
- Basic plasma physics and technologies

Several contributions have been presented on **Integrated Modelling of Tokamak Plasmas**

by Prof. Fukuyama of Kyoto Univ., Dr. A. Becoulet of CEA, France, Dr. B. Goncalves of IST/CFN, Lisbon, and Dr. Onjun from SIIT, Thailand

It is necessary to develop integrated tokamak simulation codes to predict the behavior of burning plasmas in ITER.

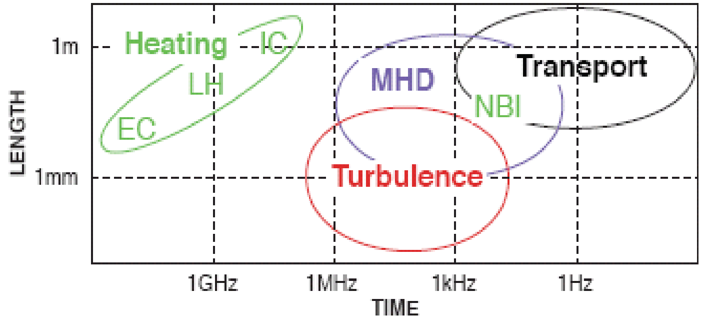
- In Japan, they are developing an integrated code, TASK, as a reference core code for the BPSI activity.
- Several examples of integrated analysis have been shown, the self-consistent analysis of ICRF heating, the integrated simulation of ITER operation scenarios, the density profile modification due to the NBI injection, and the analysis of Alfven eigenmode in a ITER plasma.

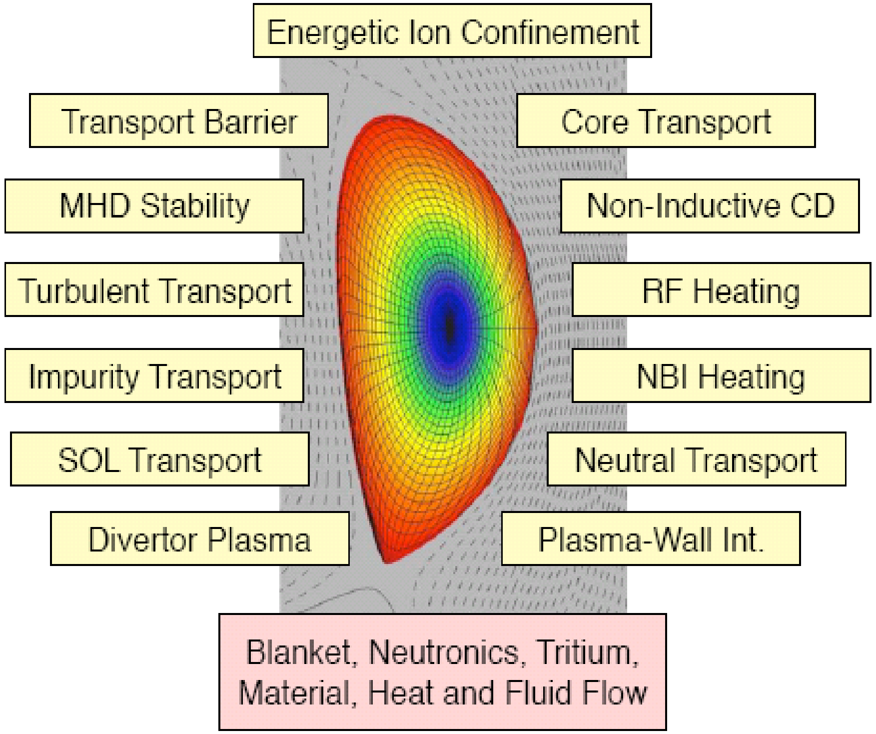
Further continuous development of integrated modeling is needed for comprehensive ITER simulation.

Simulation of Tokamak Plasmas

Broad time scale:
100GHz ~ 1000s

Broad Spatial scale:
10 μm ~ 10m



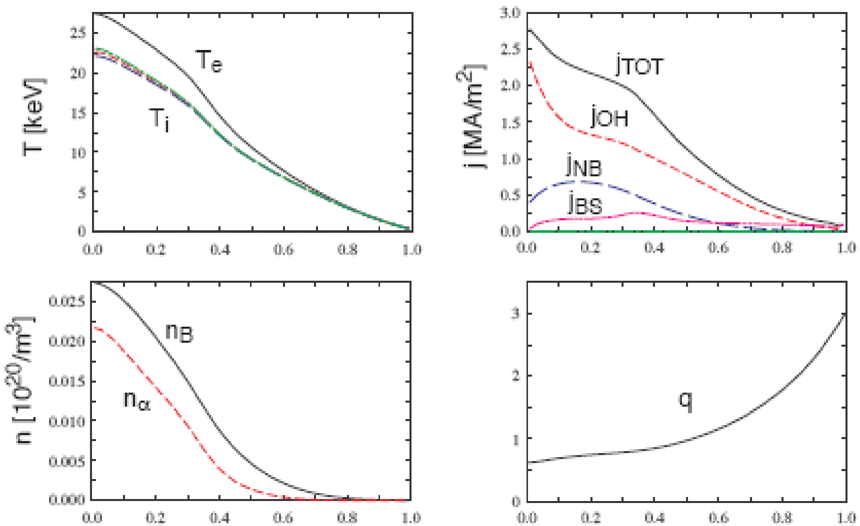


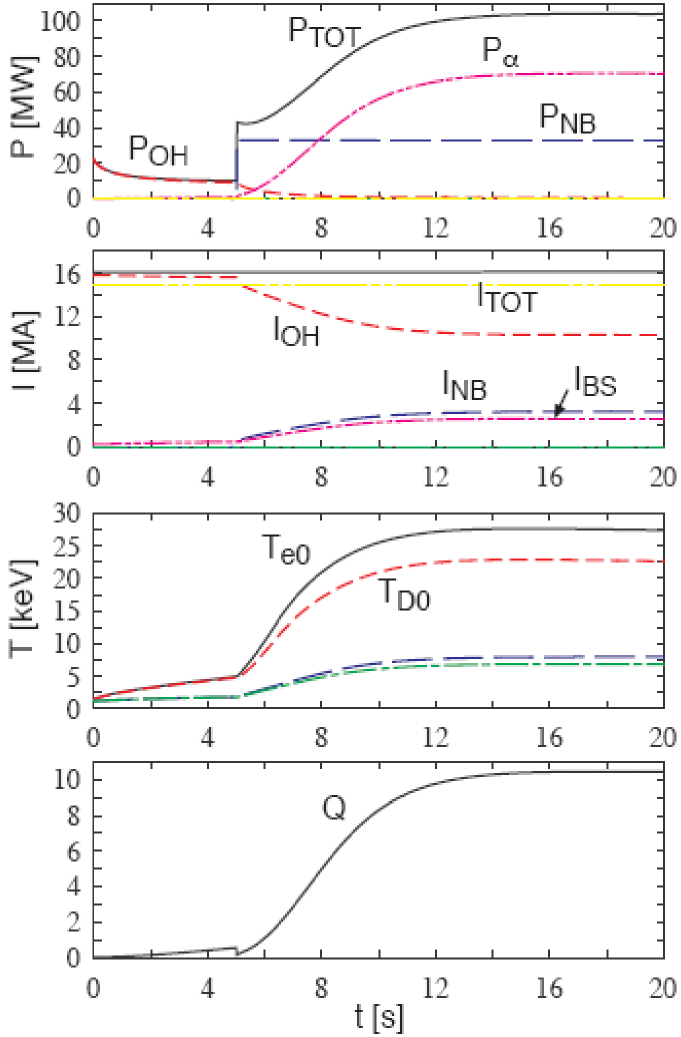
One simulation code never covers all range.

Integrated simulation combining modeling codes interacting each other

ITER High Performance Scenario

- $I_p = 15\,\mathrm{MA}$
- $P_{NB} = 33\,\mathrm{MW}$
- $\beta_N = 1.3$



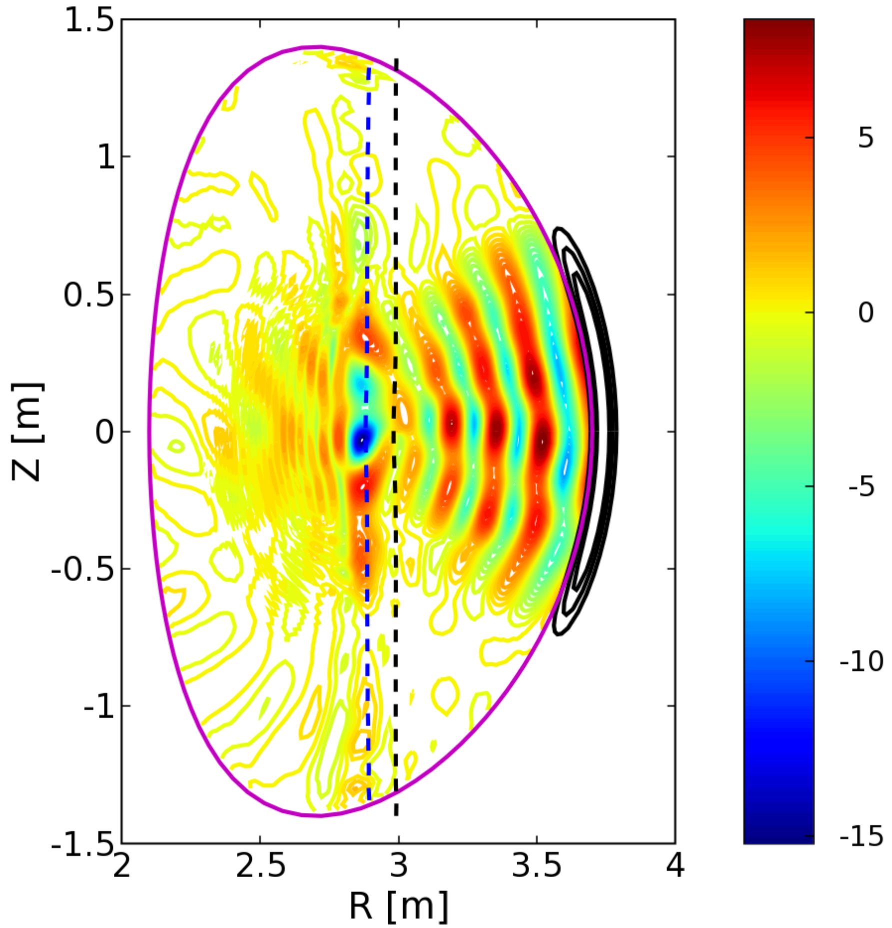


Contribution by A. Becoulet on CEA work on ITM

- The modelling needs for Magnetic Fusion Devices (present tokamaks/stellarators, ITER, DEMO reactor) are manifold:
  - « **first principles** » modelling:
    - Understanding the fundamental mechanisms
  - « **ad-hoc** » modelling:
    - Developing simplified models, parameterized and adjusted both on experimental observations and first principle results.
    - Interpreting/predicting complex experimental behaviour.
    - Towards « **integrated modelling** »
  - « **real time** » modelling:
    - Developing « ultra fast » modules for device control & operation
  - « **modelling technologies** »

EVE: a hamiltonian Full Wave code

JET: *D(H) heating (N_{tor}=15)*

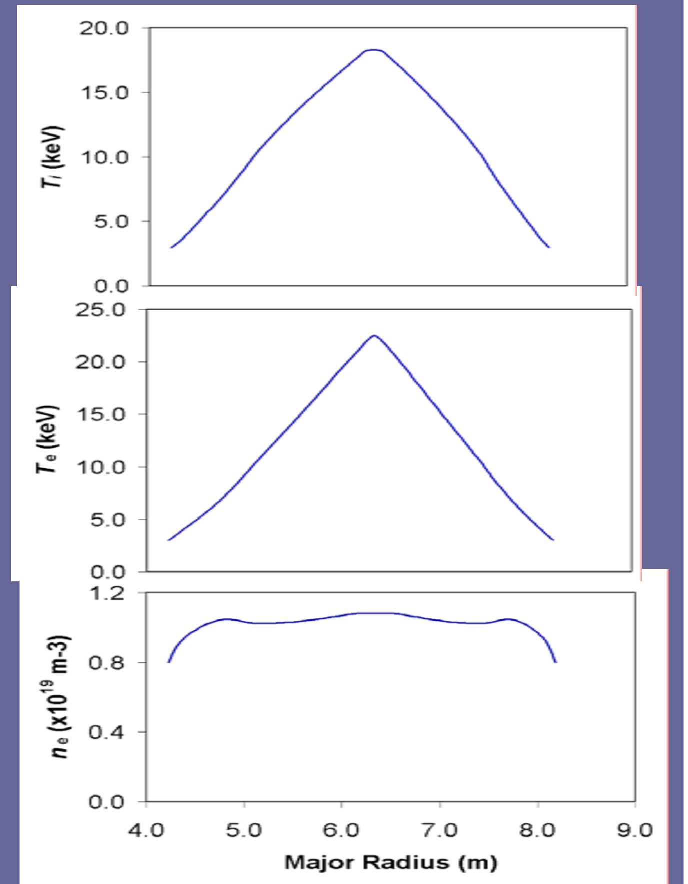


- **Main objectives**
  - ICRF waves / plasma interaction
  - Linear Alfvén waves / plasma interaction
  - Fast particle orbits effects
  - Main element of a wave + kinetic package
- **Physics features**
  - Wave equations in terms of potentials
  - Particle orbits in action-angle coordinates
  - Finite Larmor Radius expansion
- **Numerical features**
  - Parallel code
  - Finite elements code (cubic + quadratic)
  - Fourier exp. in poloidal and toroidal angles
  - Fortran 90 (core), Python (post-processing)

ITER Prediction with BALDUR code

Contribution by Dr. Onjun, SIIT, Thailand

- Simulations for ITER at the design parameters
  - Use MMM95 for core transport
  - Predicted pedestal temperature (2.7 keV) and density (0.8×10^{20} m-3)
  - Auxillary heating power of 40 MW
  - No effect of ELM crashes
- Central ion and electron temperatures are about 20 keV
- Density profile is relatively flat
- Fusion Q of 10.6

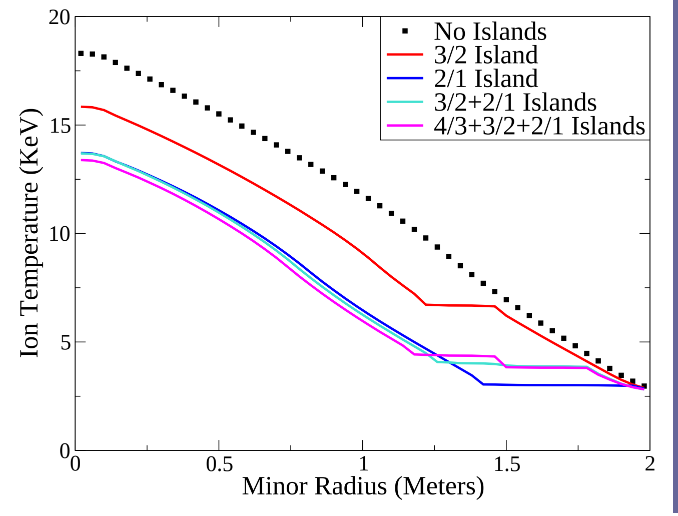


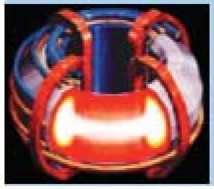
Bateman et al. Phys. Plasmas 2003

Importance of Stabilizing NTMs in ITER

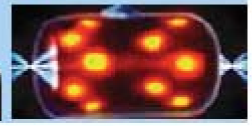
- When BALDUR simulations of ITER include saturated NTM islands it is found that
  - Central ion temperature decreases
- With multiple saturated islands
  - Fusion Q decreases from 10.6 to 2.4
  - Plasma β decreases from 2.5 to 1.4%

Scenario	$T_{i,0}$	Q	β
No Islands	18.3	10.6	2.5
3/2	15.8	6.2	2.0
2/1	13.7	2.8	1.4
3/2+2/1	13.6	2.6	1.5
4/3+3/2+2/1	13.3	2.4	1.4

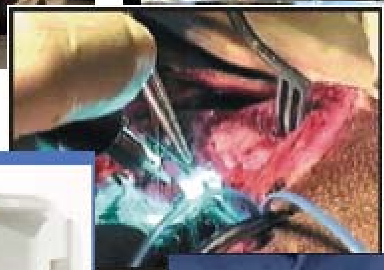


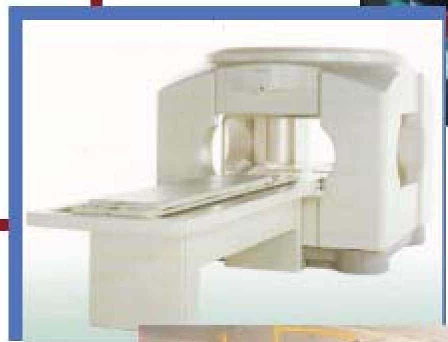


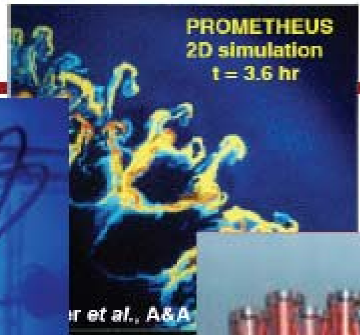
The Surprising Benefit of Creating Stars on Earth



It is apparent that the technology development that has been performed in the pursuit of fusion energy has lead to significant number of spin-offs.







Broadening Advanced Plasma Control Activities

Presentation by B. Goncalves

- Advanced Plasma Control Systems
- Fast Timing and Event Management System
- Shared Data Access System
- Generic Control and Data Acquisition System
- Hybrid (transient recorders and waveform generators) intelligent modules for CAMAC, VME, PCI, PCIe and ATCA standards;
- Unified RT Control Data Acquisition & Hardware Platform
- New concepts of data transmission and networks
- Remote operation
- Real-Time Control Systems Test-Bench
- Parallel processing techniques

Integration into small, medium and large fusion devices

Broader outreach by establishing new links with different plasma physics and fusion communities benefiting from IAEA activities

- Theoretical problems:
- Role of shear flow in magnetically confined plasmas (Dr. C.Hidalgo)
- Role of Shear flow and neoclassical polarization current in NTM stability (E. Lazzaro)
- Extensions of Analytical techniques: derivation of MHD eqs. (prof. Hosking)
- Physics of Quark-hadron phase transitions-relics from the mini bang (prof Sinha)

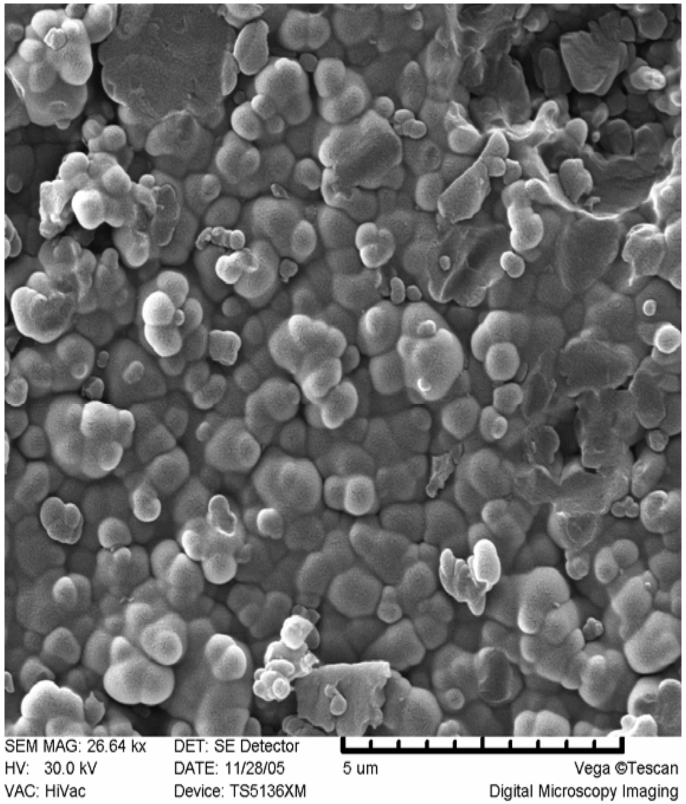
Basic Plasma Physics and Technology

- Fascinating discipline of plasma nanoscience was introduced by **Dr. Ostrikov.**
- Several technological applications of low temperature plasmas in treatment of materials (texttiles and papers) were discussed by **Dr. Barni** and **Dr. Vilaithong**.
- Physics of complex plasmas was presented by **Dr. Morfill** they have properties of soft matter, described trough phase transitions from gas to liquid to solid plasma state:
  - Supramolecular behaviour,
  - macroscopic softness
  - Metastable states
  - Comparison of behaviour of classical plasmas with that of strongly coupled ones may b striking.
  - Two stream instability corresponds to siliton generation
  - velocity space instabilities to coordinate instabilities

Technological applications push to shift towards atmospheric pressure plasma processing.

Joint effort on diagnostics, modeling and process characterization favors such shift.

As an example, organic SiOx films have been deposited in a DBD plasma and applied for improved packaging capability of paper.



A SEM image of an organic SiOx film deposited by an atmospheric pressure electrical discharge.

- Dr. Vilaithong has shown the concrete possibility of realization of large size plasma based devices for processing of silk textile.

Conclusions

- The possibility has been demonstrated of *constant spin off* from the lofty (or remote…) problems of fusion plasma physics to applicable science and technology in a wide range of parameters.

- The conference has been successful in stimulating the interests of specialists of various branches of plasma physics and in sharing their knowledge.