International Tokamak Physics Activity (ITPA)

presented by
R.D. Stambaugh

At ITPA Fusion Power Associates Meeting
Fusion: Pathways to the Future

Washington, D.C.

September 27, 2006

International Tokamak Physics Activity (ITPA)

Origin

- ITER Expert Group antecedent
- U.S withdraws from participation in ITER and the Expert Groups
- ITPA is formed by four parties (EU, Japan, Russia, US)
  - Tokamak physics toward burning plasmas
  - Broader tokamak participation
  - Connection to stellarator community
- Formed with the endorsement of the IFRC and the FPCC
- Participation through various bilateral and IEA implementing agreements

Charter

Agreed principles for conducting the International Tokamak Physics Activity (ITPA)

September 3, 2001 Coordinating Committee

The International Tokamak Physics Activity (ITPA) aims at cooperation in development of the physics basis for burning tokamak plasmas. …….achievement of a broad physics basis useful for all fusion programs, for the ITER design, and for general tokamak research worldwide.

The ITPA shall consist in providing:

- Validated experimental data according to an agreed format;
- Analyzed results of experiments to advance understanding of fusion plasma physics;
- The organization, management, and updating of qualified databases;
- Theoretical models and simulation results to explain and reproduce experimental results;
- Studies of fusion plasma performance in burning plasma tokamak devices, such as ITER; and
- Identification and resolution of key diagnostics issues which might arise both in plasma control and in analysis of a burning plasma experiment, such as ITER.

Organizational Structure

- The ITPA organization includes a Coordinating Committee and seven Topical Physics Groups. While the membership of these international Topical Groups is limited to 5 from each party in order to maintain a continuity and coherence, the meetings are open to other scientists also.

- Management support is provided by the ITER International Team

ITPA Membership - June 2006

	EU	JA	RF	US	CN	KO	IN	IT
Coordinating Committee	D. Campbell† F. Romanelli H. Zohm	Y. Nakamura† Y. Kamada† S. Takamura	N. Ivanov† S. Konovalov S. Mirnov	E. Oktay† N. Sauthoff R. Stambaugh*	Yuping Huo Jiangang Li† Chuanhong Pan	M. Kwon† J. H. Han Y. S. Hwang	P.K. Kaw Y. Saxena R. Singh	Y. Shimomura M. Shimada**
Transport Physics	J. Connor X. Litaudon R. Jaspers	T. Fujita T. Fukuda A. Fukuyama Y. Sakamoto K. Toi	Y. Esipchuk N. Kirneva S. Lebedev K. Razumova V. Vershkov	E. Doyle* P. Gohil J. Kinsey J. Rice E. Synakowski D. Mikkelsen☆	Jiaqi Dong Aike Wang Shaoji Wang Deng Zhou Younian Wang	J. Y. Kim J. M. Kwon C. M. Ryu	R. Singh V. Kumar A. Kumar	V. Mukhovatov**
Confinement Database and Modelling	D. McDonald F. Imbeaux F. Ryter C. Hidalgo☆	Y. Ogawa H. Takenaga T. Takizuka M. Yagi H. Yamada	A. Chudnovskiy Y. Dnestrovskij V. Leonov	W. Houlberg* J. Deboo S. Kaye R. Budny J. Snipes	Zhengyin Cui Jinhua Zhang Changxuan Yu Yaojiang Shi Ze Gao	J. M. Park S. H. Seo C. B. Kim	I. Bandyopadhyaya P. Chattopadhyaya R. Srinivasan	A. Polevoi**
Edge Pedestal Physics	L. Horton H. Wilson G. Saibene	K. Ida Y. Kamada* Y. Nakashima N. Oyama H. Urano N. Ohyabu*	M. Osipenko R. Shurygin	A. Leonard ** P. Guzdar A. Hubbard T. Rognlien M. Wade	Xiang Gao Longweng Yan Bili Lin Guosheng Xu	S.W. Yoon W.H. Ko G.Y. Park	P.K. Kaw R. Singh J. Govindrajan	M. Sugihara
Scrape-off-layer and Divertor Physics	A. Loarte Ph. Ghendrih A. Kallenbach W. Fundamenski V. Philipps K. McCormick☆	N. Asakura* T. Kato T. Nakano S. Takamura T. Tanabe	V. Kurnaev G. Kirnev	S. Krasheninnikov B. Lipschultz** D. Whyte M. Fenstermacher P. Stangeby	Yu Yang Yudong Pan Shizeng Zhu Jianshen Hu	S. H. Hong K. S. Chung S.S. Kim D.C. Seo J.I. Chung	S. Deshpande N. Bisai R. Singh	A. Kukushkin G. Federici

*** Chair; ** Co-Chair ; †Coordinating Committee Contact Person ; ☆Stellarator**

ITPA Membership - June 2006

	EU	JA	RF	US	CN	KO	IN	IT
MHD	T. Hender* J. Lister A. Fasoli S. Günter A. Jaun	S. Iio N. Nakajima Y. Ono T. Ozeki M. Takechi	N. Ivanov S. Konovalov V. Lukash S. Mirnov V. Pustovitov	E. Strait R. Granetz G. Navratil J. Menard W. Heidbrink E. Lazarus☆	Yi Liu Qindi Gao Liqun Hu Xiwei Hu Yuan Pan Xiaogang Wang	O.J. Kwon K.I. You J.G. Bak S.G. Lee	A. Sen D. Raju R. Ganesh A. Das	Y. Gribov** M. Sugihara
Steady State Operation	A. Bécoulet A. C.C. Sips* A. Tuccillo	S. Ide** A. Fukuyama K. Hanada T. Suzuki T. Takase Y. Nakamura*	V. Kulygin V. Vdovin A. Zvonkov	T. Luce P. Bonoli C. Kessel M. Murakami R. Prater	Xianzhu Gong Xuantong Ding Xiaodong Zhang Xianming Song Jiarong Luo	Y.S. Na B.H. Park Y.S. Bae J.G. Kwak S.W. Cho	P.K. Kaw Y. Saxena D. Chenna Reddy S. Deshpande	T. Oikawa
Diagnostics	A. Donné* F. Orsitto H. Weisen F. Serra H-J Hartfuss☆	K. Kawahata Y. Kawano Y. Kusama A. Mase M. Sasao	G. Razdobarin A. Krasilnikov V. Strelkov K. Vukolov V. Zaveriaev	D. Johnson R. Boivin G. Wurden G. McKee A. Peebles	Junyu Zhao Qinwei Yang Yan Zhou Baonian Wan Yinxian Jie	H.G. Lee W.H. Choe H.K. Na J.H. Lee Y.W. Nam	P. Vasu C.V.S Rao R. Jha P.K. Atrey	A. Costley** T. Sugie

*** Chair; ** Co-Chair ; †Coordinating Committee Contact Person ; ☆Stellarator**

The BPO Will Be the Foundation for US ITPA Participation

- US Members of ITPA will be drawn from the BPO.
- BPO work and deliberations will be input to the ITPA activities.
- US ITPA members can inform the BPO on international deliberations.
- BPO can support and facilitate priority ITPA research in the US.

Meetings and Workshops

- The Topical Groups hold about two meetings annually to review the world wide progress in their topical area, to discuss open scientific issues, and to recommend research topics that should be carried out and their priorities. One of these meetings is usually around a major international conference to minimize travel.

- The Coordinating Committee meets about once a year to review the work of Topical Physics Groups, to consolidate their recommendations, and to develop an annual list of ITPA research tasks for the world tokamak community to work on.

ITPA Meetings Completed and Planned in 2006

Topical Group	Date	Host, Country
SOL/Divertor	Jan. 9-11, 2006	Shanghai, China
MHD	Feb. 6-9, 2006	JAEA, Japan
Diagnostics	April 10-14, 2006	Moscow, Russia
Pedestal	April 10-12, 2006	PSFC, MIT, USA
SSO	April 10-13, 2006	JAEA, Japan
CDBM	April 24 -27, 2006	PPPL, USA
TP	April 24 -27, 2006	PPPL, USA
ITPA CC	June 26-27 2006	Cadarache, France
Diagnostics	September 4-8, 2006	Sendai, Japan
MHD	October 23-25, 2006	Chengdu, China
Pedestal	October 23-25, 2006	Chengdu, China
CDBM	October 23-26, 2006	Chengdu, China
TP	October 23-26, 2006	Chengdu, China
SSO	October 23-26, 2006	Chengdu, China
SOL/Divertor	November 6-9, 2006	U. Toronto, Canada
ITPA/IEA	Nov. 30- Dec. 1	JAEA, Japan

ITPA High Priority Research Tasks 2005–2006

Definition of High Priority Research Tasks: a small number of R&D tasks which provide a focus for the Topical Group's activities in a timeframe of 1-2 years and which should be determined on the basis of their likely importance, both in increasing understanding of fusion plasmas and in providing increased confidence in achieving significant fusion gain in p roposed long-pulse burning plasma facilities, as well as on the probability of achieving significant progress within this timeframe.

ITPA High Priority Research Tasks 2005–2006

Diagnostics	• Assessment of the various options for Vertical and a Radial Neutron Cameras to measure the 2D n/α source profile and asymmetries in this quantity. • Development of methods of measuring the energy and density distribution of confined and escaping α's • Assessment of radiation effects on coils used for measurements of the plasma equilibrium and development of new methods to measure steady state magnetic fields accurately in a nuclear environment. • Determination of life-time of plasma facing mirrors used in optical systems • Development of measurement requirements for measurements of dust, and assessment of techniques for measurement of dust and erosion
MHD	• Investigate underlying NTM physics including their seeding; stabilisation of (3,2) and (2,1) NTMs by direct control and by indirect methods (seed island control and FIR mechanism); and identify requirements for ITER plasmas . • Enhance understanding and mitigation of the effects of RWMs by analysis, experimental verification of control, determination of role of plasma rotation and error fields. Determine control system requirements for diagnostics. • Construct new disruption DB including conventional and advanced scenarios and heat loads on wall/targets • Develop disruption mitigation techniques, particularly by noble gas injection. • Understand intermediate-n AEs ; losses of fast particles from AEs; and perform theory-data comparisons on damping and stability. • Specify for ITER the low frequency noise in the diagnostic signals used in feedback loops of 1) the plasma vertical stabilization (noise in dZ/dt, f < 60-100Hz) and 2) the RWM stabilization (poloidal field component n=1, f < 300-500Hz).

ITPA High Priority Research Tasks 2005–2006

Steady State Operation	• Focus the modelling activity on ITER Hybrid and Steady state cases, using standard (and common) sets of input data. • Assessment of real-time control of advanced scenarios in ITER, with collaboration on experiments and modelling.
Transport Physics	• Understand and optimize transport properties of hybrid and steady-state demonstration discharges • Address reactor relevant conditions and dimensionless parameters e.g., electron heating, $T_e \sim T_i$, low momentum input, He/impurity transport, edge-core interaction • Utilize international experimental databases in order to test commonality of transport physics in hybrid, steady state scenario and reactor relevant conditions • Test simulation predictions via comparisons to measurements of turbulence characteristics, code-to-code comparisons and comparisons to transport scaling.
Confinement Database and Modelling	• Resolve the differences in β scaling in H-mode confinement • Define a program to understand the density peaking • Develop a reference set of ITER scenarios for standard H-mode, steady-state, and hybrid operation and submit cases from various transport code simulations to the Profile DB • Resolve which is the most significant confinement parameter, ν^* or n/n_G • Understand the aspect ratio dependence of the L-H power threshold

ITPA High Priority Research Tasks 2005–2006

Pedestal and Edge	• **Improve predictive capability of pedestal structure through profile modeling of joint experimental comparisons** - Dimensionless cross machine comparisons to isolate physical processes; Rotation, Er, shape, etc - Measurement and modeling of inter-ELM transport - Establish profile database for modeling joint experiments • **Physics based empirical scaling** - Collaboration with CDBM to improve scalar database characteristics and utilization • **Predict ELM characteristics and develop small ELM and quiescent H-mode regimes and ELM control techniques**
Divertor and SOL	• **Understand the effect of ELMs/disruptions on divertor and first wall structures.** • **Improve understanding of Tritium retention & the processes that determine it and development of efficient T removal methods.** • **Improve understanding of SOL plasma interaction with the main chamber.** • **Develop improved prescription of SOL perpendicular transport coefficients and boundary conditions for input to BPX modelling**

Worldwide Planning of Joint Experiments
ITPA-IEA Joint Experiment Planning

- A meeting took place in November 2002 at MIT at which representative of the ITPA CC met with the tokamak program leaders from the IEA Large Tokamak and Poloidal Divertor Implementing Agreements to devise a process to foster increased joint experiments – experiments that require the closely coordinated work on two or more tokamaks. The resulting process has grown to involve all the IEA implementing agreements and nearly all tokamaks.
- In the fall of each year, the ITPA, through its Topical Groups, prepares a report on the previous year's joint experiments and a proposal for a set of joint experiments for the coming year.
- The ITPA CC chair, assisted by the TG chairs, presents this proposal to the world's tokamak program leaders in a meeting in the December time frame.
- At this meeting, the joint experiments are discussed. Commitments are sought from the various tokamak program leaders expressed as a color code
  - Red means the machine is committed to the experiment
  - Green means the experiment is being considered – probably will be done
  - Blue means the machine probably will not do this experiment.
- An international participant team is identified and a spokesperson defined.
- The tokamak leaders seek to implement these joint experiments within their normal experimental planning processes.

ITPA/IEA Joint Experiment Planning

TP-6.1	Transport Physics	Scaling of spontaneous rotation with no external momentum input	J. Rice (CMOD), J. deGrassie (DIII-D), F. Crisanti, L.G. Eriksson (JET), Y. Koide (JT-60U), B. Duval (TCV), A. Field(MAST), C. Fenzi (Tore-Supra), B. LeBlanc(NSTX), J. Noterdaeme(AUG)	CMOD, DIII-D, JET, JT-60U, Tore-Supra, TCV, FTU, MAST, NSTX, AUG	E	Data is not routinely obtained on machines. Even Ohmic data is valuable.
TP-6.2	Transport Physics	JT-60U/DIII-D Mach number scan similarity experiment	C. Petty (DIII-D), E. Doyle (DIII-D), Y. Koide (JT-60U)	DIII-D, JT-60U	E	Co- Counter NBI used to control Mach number
TP-6.3	Transport Physics	NBI-driven momentum transport study	P. Gohil (DIII-D), J. Fujita (JT-60U), M. Peng (NSTX), A. Field (MAST)	DIII-D, JT-60U, NSTX, MAST, AUG	D	Additional definition should be done.
TP-7	Transport Physics	Measure ITG/TEM line splitting and compare to codes	F. Ryter/ C. Angioni (AUG), J. DeBoo/R. Waltz (DIII-D), V. Vershkov (T-10), C. Bourdelle(Tore-Supra)	AUG, DIII-D, T-10, Tore-Supra, JET	E	Report
TP-8.1	Transport Physics	ITB Similarity Experiments	M. Peng (NSTX), A. Field (MAST)	MAST, NSTX	E	Report
TP-8.2	Transport Physics	Investigation of rational q effects on ITB formation and expansion	M. Austin (DIII-D), E. Joffrin (JET), K. Razumova(T-10), T. Donne (TEXTOR), E. Joffrin(Tore-Supra)	JET, DIII-D, T-10, TEXTOR, TCV, Tore-Supra, FTU, C-mod	E	Report, Multi-machine discussions of the physics encouraged
TP-8.3	Transport Physics	JT-60U/JET ITB Similarity Experiment	Y Sakamoto (JT-60U), P de Vries/X. Litaudon (JET)	JET, JT-60U	E	
TP-8.4	Transport Phsyics	T-10/TEXTOR ITB Similarity Experiments	T. Donne (TEXTOR), K. Razumova (T-10), O. Sauter (TCV)	T-10, TEXTOR, TCV, C-mod	E	
TP-9	Transport Phsyics	H-mode aspect ratio comparison	B. LeBlanc(NSTX), C. Petty (DIII-D), M. Valovic/A. Field (MAST)	NSTX, DIII-D, MAST,T-10	E	Report

Progress In The ITER Physics Basis

Ch.	Title	Responsible TGs	Editors, Chairs and Cochairs (†: language, *: reference)
1	Overview and Summary	M. Shimada, V. Mukhovatov and Editors	M Fujiwara, N Uckan†, M. Shimada*, V. Mukhovatov
2	Plasma confinement and transport	Transport, CDB&M, Pedestal&Edge	N Kirneva, M Nagami, E. Doyle†, W. Houlberg†, Y. Kamada, A. Leonard†, V. Mukhovatov, A. Polevoi*
3	MHD stability, operational limits and disruptions	MHDD&C, Pedestal&Edge (ELM)	V Pustovitov, J Wesley†, O. Gruber, Y. Gribov*
4	Power and particle control (including tritium retention issues)	Divertor&SOL, Pedestal&Edge (ELM)	K Lackner, M Shimada, N. Asakura*, B. Lipschultz†
5	Physics of energetic ions	SSO&EP	D Campbell, N Uckan, C. Gormezano†, S. Ide*
6	Steady-state operation (including heating and current drive)	SSO&EP, Transport	M Fujiwara, N Kirneva, C. Gormezano†, S. Ide*
7	Measurement of plasma parameters	Diagnostics	D Campbell, M Nagami, T. Donne, A. Costley†*
8	Plasma operation and control	MHD, Diagnostics, SSO&EP, Divertor & SOL (wall conditioning)	V Pustovitov, J Wesley†, O. Gruber, Y. Gribov*
9	Opportunities for reactor scale experimental physics	IT Physics Unit (M. Shimada)	K Lackner, N Uckan†, M. Shimada, V. Mukhovatov*

5 July 2004, Prepared by M Shimada

The ITPA CC Expresses its Thanks to Those Who Prepared the Progress In The ITER Physics Basis

Shimada, Michiya
Asakura, Nobuyuki
Campbell, David
Costley, Alan
Donne, Tony
Doyle, Ed
Fasoli, Ambroglio
Fujiwara, M.
Gormezano, Claude
Gribov, Yuri
Gruber, Otto
Hender, Tim
Houlberg, Wayne
Ide, Shunsuke
Kamada, Yutaka
Kirneva, Natalia
Lackner, Karl
Leonard, Tony
Lipschultz, Bruce
Loarte, Alberto
Mukhovatov,Vladimir
Nagami, Masayuki
Polevoi, Alexei
Pustovitov, Vladimir
Uckan, Nermin
Wesley, John

ITPA and ITER are Addressing Various Structure Issues and the Relation of ITPA and ITER

- Scope of ITPA Activities
- Membership in ITPA, definition of, process for adding members.
- Interface between ITPA CC and ITER IT.
- Composition of the ITPA CC
- Process for selection and change of TG chairs and co-chairs.
- Relation of ITPA Topical Groups to ITER Science Directorate.
  - Efficiency of interaction with ITER IT
  - Reduced overlaps between TGs
  - Design support, more integrated scenario work and integrated modelling?
  - More Working Groups to cross Topical Group boundaries?
- Linkage between ITPA meetings and major conferences or ITER centers

ITPA Will Provide Input into the ITER Design Review

- PDDG Nominee Holtkamp has invited the participation of ITPA in the ITER Design Review.
- Participation is planned in two forms
  - Formal input of a set of Issue Cards from the ITPA CC
  - Placing ITPA members on the ITER Working Groups
- Formal set of Issue Cards to be developed this fall
  - An electronic Working Group prepares of set of candidate issues
  - All the Topical Groups in their fall meetings consider all the issues.
  - Topical Groups add to and alter the set of issues.
  - ITPA CC meeting during IAEA in Chengdu to select the final set of issues and transmit them to ITER IT for the December Design Review meeting in Cadarache.
- ITPA input can have unique value as coming from an internationally formed consensus of scientists.

ITPA Website http://itpa.ipp.mpg.de/

ITPA

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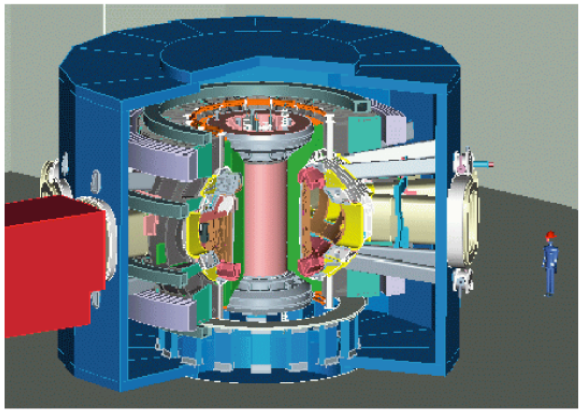
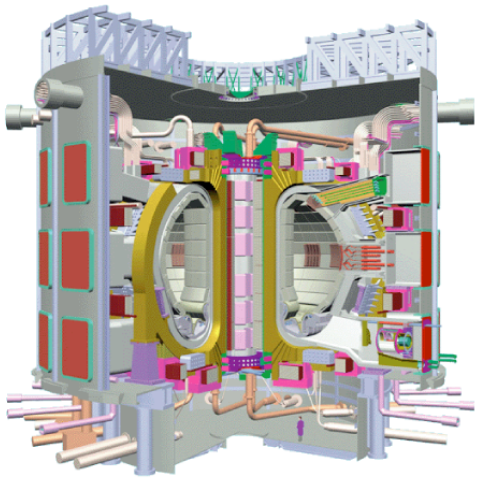
webmaster

Welcome to the ITPA WWW site





The **I**nternational **T**okamak **P**hysics **A**ctivity (**ITPA**) aims at cooperation in development of the physics basis for burning tokamak plasmas. The ITPA continues the tokamak physics R&D activities that have been conducted on an international level for many years resulting in achievement of a broad physics basis useful for all fusion programs, for the ITER design, and for general tokamak research worldwide.