Australian ITER Forum

Towards an Australian involvement in ITER

“Towards an Australian involvement in ITER”

11-13 October Sydney, Australia

On behalf of the organising committee, it is with great pleasure that we welcome you to the Australian ITER Forum Workshop, “Towards an Australian Involvement in ITER”. To our many distinguished international guests we extend a particularly warm welcome to Sydney and Australia. We will do our best to ensure that you have a pleasant few days with us.

Fusion, the process that lights the sun, combines light nuclei under extreme pressure to liberate energy. Its successful utilization on earth would see abundant and clean power for more than a million years. ITER (latin for “the Way”) is an international collaboration to build the first fusion science experiment capable of producing a self-sustaining fusion reaction. It is the next essential step on the path to achieving clean, safe, renewable electrical energy.

Australia has a tradition of excellence, discovery and innovation in fusion energy development. From the time that Sir Mark Oliphant (an Australian) co-discovered the first fusion reactions in 1934, Australia and her people have made significant advances in fusion science. The Australian ITER Forum is a collection of scientists and engineers from multiple research disciplines and institutions whose objectives are

1. To promote an Australian involvement in ITER and articulate the benefits to Australia,
2. To promote the science of fusion energy and
3. To advance the recognition of fusion science and plasma physics in the wider scientific community.

The purpose of this workshop is to bring together members of the ITER parties, Australian scientists, industry, media and decision makers in order to formulate a path for Australian involvement in ITER.

We are very proud to have the Chief Scientist of Australia, Dr Jim Peacock opening the workshop. Presentations from each of the ITER parties will set the context for the workshop. The program also covers most of the key areas where Australia could make a contribution to the ITER program. We have attempted to allow sufficient time for participants to gather informally to discuss issues of concern and for international delegates to meet and talk with Australian government.

The program concludes with a panel-based discussion forum moderated by Tim Dean, a well-respected media commentator and former editor of PCAuthority. The panel discussion will be an opportunity for all participants to ask questions of the panel and to comment on the prospects of, and pathways towards an Australian involvement in ITER.

The social program opens with registration and an informal reception on Wednesday evening between 6:30-8:30 pm. The highlight will be the workshop dinner commencing with drinks at 7:00pm on Thursday evening. The dinner speaker will be Dr George Collins, Chief of Research at the Australian Nuclear Science and Technology Organisation, and former plasma physicist.

On behalf of the organising committee, we wish all participants a pleasant stay and welcome your participation in what we hope will be a most successful workshop.

Matthew Hole (Workshop chair)

John Howard (program chair)

Sponsors

This workshop is principally supported by the Australian Department of Education, Science and Training International Science Linkages Scheme established under the Australian Government's innovation statement, *Backing Australia's Ability*.

An Australian Government Initiative

Backing Australia's Ability

ANU THE AUSTRALIAN NATIONAL UNIVERSITY

The UNIVERSITY of NEWCASTLE AUSTRALIA

H-1NF

Australian Research Council COSNet Complex Open Systems Research Network

The University of Sydney AUSTRALIA

AINSE

Australian Institute of Nuclear Science and Engineering

MURDOCH UNIVERSITY PERTH, WESTERN AUSTRALIA

University of Wollongong

Australian Government ansto

Australian Nuclear Science and Technology Organisation

The Australian ITER Forum

The Australian ITER Forum is a collection of scientists and engineers from multiple research disciplines supporting a mission oriented goal of controlled fusion as an energy source

Objectives

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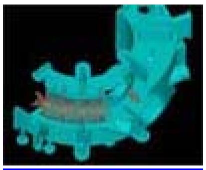
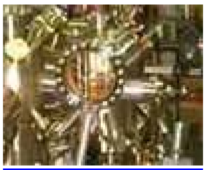
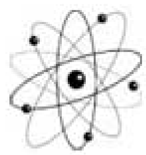
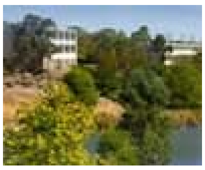
2. To promote the science of fusion energy.
3. To advance the recognition of fusion science and plasma physics in the wider scientific community.

Membership and Research Areas

	Member	Location	Research Area
	University of Sydney	Sydney	• Quasi-toroidal pulsed cathodic arc • Plasma theory/ diagnostics
	Australian National University	Canberra	• H-1 National Facility • Plasma theory program
	University of Newcastle	Newcastle	• High heat flux alloys • Testing first wall materials using 10keV D and He bombardment
	Murdoch University	Perth	• Electron, photon collisions with atoms
	Flinders University	Adelaide	• Computational MHD modelling
	University of Canberra	Canberra	• Plasma fuelling, • Soft x-ray imaging
	University of Wollongong	Wollongong	• Metallurgy • Welding • Surface engineering

 ANSTO	Sydney	• Manages OPAL research reactor • ~1000 staff
AINSE	Sydney	• Australian and New Zealand University and ANSTO Membership

Workshop Organising Committee

Chair	Dr Matthew Hole , Australian National University matthew.hole@anu.edu.au
Treasurer	Prof. John O'Connor, University of Newcastle john.oconnor@newcastle.edu.au
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Member	Dr Boyd Blackwell, Australian National University
Member	Prof. Andrew Cheetham, University of Canberra
Member	Prof. Brian James, University of Sydney
Member	Ross Calvert, Australian Institute of Energy
Member	Lynne Hunter, European Commission to Australia & New Zealand

General Information

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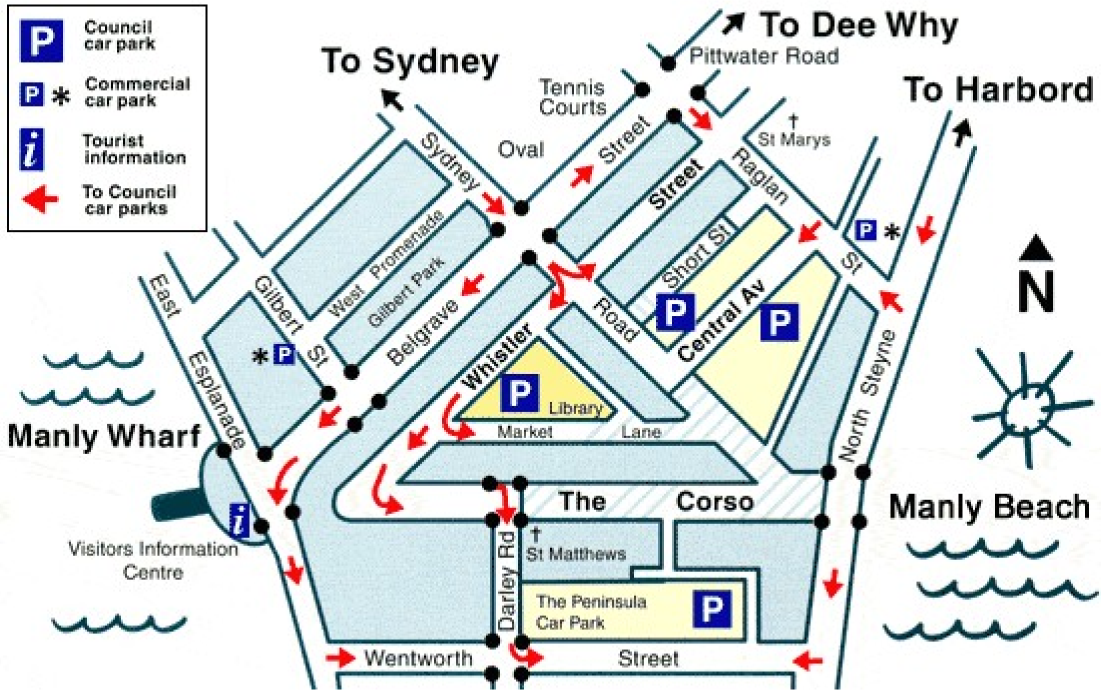
Located right on spectacular Manly Beach, one of Australia's most famous beaches, and only 15 minutes to Circular Quay by Jetcat. The hotel features 218 rooms, a restaurant, cocktail bar, rooftop swimming pool, gymnasium, sauna and spa. Relax and indulge in the tranquility of this ocean front hotel with wonderful views of the Pacific Ocean and with extensive dining and entertainment venues in the nearby Manly Corso



Banks

Banks in Sydney are open from 0930 to 1600 Monday to Thursday and 0930 to 1700 on Fridays. Banks are closed all day Saturday and Sunday. Automatic Teller Machines are plentiful.

Eating Out

Manly's multicultural population is reflected in the wide variety of excellent restaurants offering a diversity of cuisine from around the world. Local seafood delicacies are recommended and include Sydney Rock Oysters, King Prawns, Queensland Mud Crab, Balmain Bugs and Barramundi.

Electricity

The electrical supply is 240 volts, 50Hz. The connection for appliances is a flat 3-pin plug of unique design. Converter plugs for electrical devices from major countries can be purchased at Sydney Airport and tourist outlets.

Public Transport

An extensive public transport system (bus, train and ferry) enables visitors to enjoy many areas of Sydney at reasonable prices. For details on fares, timetables, routes and a trip planner:

Transport from the airport

1.Manly Airport Bus (advance bookings recommended): 12-seater door-to-door minibus service. To book, e-mail (preferred) or tel. 0500 505 800 (within Australia). Specify name, time of arrival and flight number. All pre-booked passengers are met with a sign, but there are also designated meeting points -- Domestic: in front of Qantas Carousel 5; International: between exit gate "A" and McDonalds.

2. Train and ferry: Trains are available from the Domestic and International Airport Terminals to Circular Quay Railway Station (Journey approximately 19 minutes). Alight and walk to Circular Quay No. 3 Wharf and take the Ferry to Manly (journey approximately 30 minutes) or take the Manly Jetcat from Wharf

2.Sydney Ferries operate ferries and Jetcat services to Manly Wharf. Disembark Ferry and walk or catch a taxi to your destination. The conference hotel is situated on North Steyne, a 10 minute walk from the ferry terminal

3. Taxi: Taxis are readily available at both domestic and international terminals (approximate cost AUD$65 - 70)

Internet Connections

Wired broadband in all rooms cost $27.50 per user per day. Wireless internet is available at the workshop level for a similar cost.

Shopping

Shops open from 0900 to 1730 during the week with late night shopping on Thursdays to 2100. On Saturdays and Sunday most shops are open between 0900 and 1600. Sydney is considered an excellent duty-free port for travellers.

Taxes

A Goods and Services Tax (GST) of 10% applies to all consumer goods and is included in retail prices.

The Australian ITER Forum

"Towards an Australian involvement in ITER"

Technical program

Wednesday, October 11, 2006	
6:30 pm to 8:30 pm	Registration and Reception
Thursday, October 12, 2006	
8:20 am to 8:40 am	Workshop opening, **Chief Scientist of Australia, Prof Jim Peacock**
Session 1	**Chair: Prof J O'Connor (University of Newcastle)**
8:40 am to 9:20 am	**Dr D Gambier** Overview of the ITER program and current status
9:20 am to 9:50 am	**Dr M Hole** Fusion energy for future generations: The case for an Australian involvement in the ITER program
9:50 am to 10:20 am	**Dr D Campbell,** Key ITER physics issues
10:20 am to 10:40 am	Morning tea
Session 2	**Chair: Prof A Cheetham (Canberra University)**
10:40 am to 11:10 am	**Dr M Mori**, Status of ITER Technical Activities in Japan
11:10 am to 11:35 pm	**Dr B Blackwell,** H-1NF: The National Plasma Fusion Research Facility
11:35 pm to 12:05 pm	**Prof N Sauthoff** Status of ITER Technical Activities in the USA
12:05 pm to 12:30 pm	**Prof B James,** Plasma physics at the University of Sydney
12:30 pm to 1:30 pm	Lunch
Session 3	**Chair: Dr B Blackwell (Australian National University)**
1:30 pm to 2:00 pm	**Dr S Itakura**, ITER and the Broader Approach Program
2:00 pm to 2:30 pm	**Dr S Clement-Lorenzo**, EU Accompanying Program to ITER
2:30 pm to 2:55 pm	**Prof R Dewar,** Plasma theory and modeling in Australia
2:55 pm to 3:20 pm	**Dr D Fursa,** Modeling of electron-atom scattering: benchmark calculations for fusion research
3:20 pm to 3:50 pm	Afternoon tea
Session 4	**Chair: Prof B James (University of Sydney)**
3:50 pm to 4:20 pm	**Dr A Costley,** ITER diagnostics
4:20 pm to 4:45 pm	**Dr J Howard,** Australian diagnostics systems and expertise
4:45 pm to 7:00 pm	Break
7:00 pm to 11:00 pm	Dinner

Friday, October 13, 2006	
8:45 am to 8:50 am	**Announcements**
Session 5	**Chair: Dr M Hole (Australian National University)**
8:50 am to 9:20 am	**G Whitbourn,** Project Management of the OPAL Research Reactor
9:20 am to 9:50 am	**Prof LUO Delong**, Nuclear fusion programs and ITER related work in China
9:50 am to 10:20 am	**Prof S Mattoo**, Status of Procurement Packages of India
10:20 am to 10:40 am	Morning tea
Session 6	**Chair: Dr G Collins (Australian Nuclear Science and Technology Organisation)**
10:40 am to 11:10 am	**Prof A Jackson**, The Challenges of Building a Synchrotron Based Facility in Australia
11:10 am to 11:40 am	**Dr D Campbell,** EU Fusion Technology R&D
11:40 am to 12:05 pm	**Prof J O'Connor,** ITER-relevant materials research in Australia
12:05 pm to 12:30 pm	**Dr D Nolan**, Welding and surface engineering research at University of Wollongong, and its relevance to fusion energy infrastructure
12:30 pm to 2:00 pm	Lunch.
Session 7	**Chair: Dr J. Howard (Australian National University)**
2:00 pm to 2:25 pm	**Prof I Cairns,** Australian space plasma physics and its relevance to ITER
2:25 pm to 2:50 pm	**Prof S Vladimirov,** Complex plasma research in Australia
2:50 pm to 3:20 pm	**Prof C Boucher,** Canadian Fusion Energy Initiative – A continuation of fusion research in Canada
3:20 pm to 3:45 pm	Afternoon tea
3:45 pm to 4:45 pm	**Panel discussion (Tim Dean moderator) and concluding remarks**

Overview of the ITER programme: current status

Didier Gambier
Directorate General Research, European Commission

In this presentation, an overview of the development of the ITER project is given, including a brief history of the project and the negotiations that have led to an Agreement between seven Parties for the construction of ITER in Cadarache, France. The ITER Agreement, which will be signed in November 2006, contains provisions regarding the contributions of each Party, the establishment of the international organisation, the membership, the governance, the liability, and the compliance with peaceful uses and non-proliferation. The time schedule, the respective roles of the ITER Organisation and of the Domestic Agencies and the possibilities for collaboration for third Parties will be presented.

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Fusion energy for future generations: The case for an Australian involvement in the ITER program

M. J. Hole
Chair, Australian ITER Forum, The Australian National University

Fusion research has entered a renaissance era. In response to the challenges of climate change, dwindling fossil fuel reserves and the need for energy security, many governments have accelerated R&D programs in sustainable energy generation technologies. Australia, being richly blessed with a variety of sustainable energy options, is wisely developing a number of these technologies to reduce our domestic emissions. Climate change, however, is a global phenomenon requiring a global and integrated response which addresses base-load energy generation. Fusion power, which has the potential to provide clean base-load power for future generations will be advanced via ITER, a project supported by governments representing over half the world's population.

Australia has a tradition of excellence, discovery and innovation in fusion energy development. An Australian, Sir Mark Oliphant co-discovered the first fusion reactions in 1934. Since that time, Australia and her people have made significant advances in fusion science. Examples include innovative current drive techniques, the development of the spherical tokomak and heliac concepts and advances in theory and diagnostic instrumentation. In parallel with this, and driven by the resources sector, Australia has also rapidly accelerated its materials science research programs.

ITER poses great challenges both for plasma science and materials technologies. Australia can solidify its role in the international fusion program by combining and growing its expertise in both areas, and in so doing, pave the way for Australian industrial involvement in ITER.

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Key ITER physics issues

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ITER is a critical step in the development of fusion energy. Its role in the international programme to realize the potential of magnetic confinement fusion for the production of energy for peaceful purposes is to provide an integrated demonstration of the physics and technology required for a fusion power plant. The tokamak is designed to achieve a fusion amplification factor, Q, of 10 for several hundreds of seconds with a nominal fusion power output of 500MW. It is also intended to allow the study of steady-state plasma operation, at Q=5, by means of non-inductive current drive, in anticipation of a requirement for fusion power plants to operate continuously.

Operation of ITER will open new frontiers in fusion research involving the influence of a significant α-particle population on plasma heating, confinement properties and stability. Studies in steady-state scenarios expected to form the basis for operation of a fusion power plant will be of particular significance and should provide access to novel aspects of non-linear phenomena in magnetically confined plasmas. To develop plasma scenarios in which high fusion power production is combined with high confinement and plasma pressure, control of heat and particle fluxes, active control of mhd stability and fully non-inductive current drive, the fusion community will need to confront a range of challenges involving plasma physics understanding, plasma measurement techniques, auxiliary heating and current drive systems, and plasma control. The presentation will discuss key physics issues which are the subject of ongoing R&D, and review the opportunities and challenges involved in the successful operation of ITER.

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Status of ITER Technical Activities in Japan

M. Mori
Leader, ITER Project Management Group, Division of ITER Project, Japan Atomic Energy Agency (JAEA), JAPAN

Japan has participated in ITER project since the beginning of the Conceptual Design Activities (CDA) in 1988. Japan Atomic Energy Research Institute (JAERI), as an implementing institute designated by the Japanese government, has contributed to the CDA, Engineering Design Activities (EDA) and succeeding technical activities, by not only sending many Japanese experts to the International Team but also sharing a lot of technical tasks in collaboration with Japanese industries, research institutes and universities. As for physics activities, many experts in JAERI or JAEA created from the merge of JAERI and Japan Nuclear Cycle Development Institute in 2005, National Institute for Fusion Science and Japanese universities have actively participated in and contributed to the ITER EDA Physics R&D activities and International Tokamak Physics Activities on a voluntary basis with lots of experimental data from JT-60U and other experimental devices and analyses. In parallel with ITER activities, R&D for Japanese blanket modules to be tested in ITER operation has been and is being promoted as an ITER-related domestic program to prepare the technology for tritium breeding blanket in DEMO. Japan is promoting ITER project, ITER-related activities above and other fusion research activities as national programs based on “The Third Phase Basic Program for Fusion Research and Development” adopted by Japan Atomic Energy Commission.

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H-1NF: The National Plasma Fusion Research Facility

Boyd Blackwell
Plasma Research Laboratory, Australian National University

Australian research in support of plasma fusion covers a wide range of fields, encompassing material science and atomic physics as well as basic experimental and theoretical plasma physics. These will be covered in more detail in later presentations. The focus of Australian toroidal plasma confinement research is the ***H-1 National Plasma Fusion Research Facility***, based on the H-1 Heliac device, which was upgraded in the first round of the Major National Research Facilities funding. H-1NF is ideal for basic research into advanced plasma shapes for the generation of devices following the ITER tokamak. In addition to providing a "test-bed" for plasma diagnostics, described in a separate presentation, and plasma conditions similar to edge plasma in a reactor, H-1 allows investigation of several fusion plasma phenomena on a smaller scale. Transitions to a "high confinement" mode reported by Shats, reproduce most of the characteristics of those found in the largest machines, but are more conveniently accessed, and allow detailed examination of the physics involved. Phenomena closely related to the fast particle driven Alfvén eigenmodes are also observed in H-1. The great flexibility in rotational transform and shear, in conjunction with the world's only fully tomographic 2-d imaging plasma interferometer for plasma density measurement allows unequalled precision in the prediction of the Alfvén dispersion relation which is at the heart of these instabilities.
Results and future directions will be discussed.

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Status of ITER Technical Activities in the USA

Ned R. Sauthoff
US ITER Project Office, Oak Ridge National Laboratory

This talk will describe the US experiences and lessons learned in its path from first consideration of entry into ITER Negotiations to the present, with the goal being to provide some examples and insights to the Australian fusion community. Starting in 2001, the US fusion community engaged in a series of activities that involved both the scientific/technical communities and the US government, leading to the favorable decision on US entry into ITER Negotiations. In 2003, the parties developed draft arrangements, including assignment of hardware responsibilities to the parties. In 2005, the arrangements were finalized and the hardware assignments were revised to accommodate entry of India as a full partner. Since then, the US has focused on (1) the creation and development of its US Domestic Agency, (2) advancement of the R&D and design of components assigned to the US, (3) providing staff to the ITER International Team, and (4) providing cash to the ITER team. Developments in the hardware will illustrate trends and seemingly productive approaches to international joint work.

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Plasma Physics at the University of Sydney

Brian James
School of Physics, University of Sydney
NSW Australia 2006

Plasma Physics has been a major research area in the School of Physics at the University of Sydney since the early 1960s. Initially the emphasis was on plasma waves and the development of spectroscopic and laser-based diagnostic techniques, particularly those involving the far infrared part of the spectrum. Around 1980, with the construction of the tokamak TORTUS, there was a focus on Alfven wave modes in toroidal systems and the use of far-infrared lasers and tunable gyrotrons for investigating these modes using coherent scattering. At the same time the Sydney group developed expertise in high resolution emission spectroscopy and hook interferometry for application to low temperature processing plasmas. With the decommissioning of TORTUS in 1995, fusion related activities shifted to participation in the national program associated with the H-1 heliac, with the Sydney group taking responsibility for the development of a pulsed supersonic helium diagnostic beam.

The School has had a long term interest in the use of plasmas for thin film deposition and surface modification, and this forms today the basis for a vigorous program in plasma-materials interaction based on the use of rf plasma sources and magnetic filtered vacuum arcs. More recently there have been experimental and theoretical programs in complex plasmas established, as well as a diagnostic study of IEC discharges used as compact neutron sources. The School has also had long standing research in the plasma field via programs in space physics and theoretical astrophysics.

These programs have involved numerous international collaborations. Perhaps the most notable, in the context of the present workshop, was the development of a scanning interferometer for ECE diagnostics on JET.

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Broader Approach Project

S. Itakura
Director, Office of Fusion Energy, Ministry of Education, Culture, Sports, Science and Technology, JAPAN

The Broader Approach (BA) Project is a complementary R&D project to be conducted in parallel with ITER project toward the realization of fusion Demo reactor. It will be implemented under the cooperation between Japan and Europe. The BA project consists of three main activities; (1) the Engineering Validation and Engineering Design activities in Rokkasho for the International Fusion Materials Irradiation Facility (IFMIF-EVEDA), (2) the design and R&D coordination activities of the fusion demo reactor in Rokkasho for the International Fusion Energy Research Centre (IFERC) and (3) the Satellite Tokamak Programme in Naka. Theses activities in parallel with ITER project are essential for realization of fusion power plant. Participation in the BA research activities would be opened also for the researchers from the other ITER parties. In addition to ITER project, Japan contributes for the realization of Demo reactor through the BA project in cooperation with Europe.

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EU Accompanying Programme to ITER in Fusion Energy Research

Susana Clement Lorenzo
Directorate General Research, European Commission

The long-term objective of the European fusion programme is the harnessing of the power of fusion to help meet mankind's future energy needs. This presentation describes the context of European fusion research, the unique organisational character of the programme, and current activities, including developments concerning ITER. An overview of the reorganisation of the programme in view of the construction in of ITER in Europe, its aims, structure and principal activities under the 7th Euratom Framework Programme is presented.
The European fusion programme is an integral part of the EU's research policy, expressed through the Framework Programmes, and embedded in the context of the policy of sustainable development. Participation in the programme is open to all EU Member States, plus third countries which have made an agreement with Euratom. A further structure, the European Fusion Development Agreement (EFDA), a framework contract between Euratom and its usual partners in fusion (the Associates) has been established to coordinate: (i) technology activities carried out by the Associations and by European industry; (ii) the collective use of the Joint European Torus (JET) facilities; and (iii) European contributions to international collaborations such as ITER. With the oncoming construction of ITER, new structures are being established to implement the EU fusion programme.

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Fusion-related theory and modelling in Australia

R.L. Dewar
Convenor, ARC Complex Open Systems Research Network (COSNet)
The Australian National University (ANU)

Fusion-related theory work in Australia is based in several universities, with strong international linkages, and ranges from plasma physics to atomic and molecular physics. The strong national support for high-performance computing in Australia provides a resource for numerical work.

In plasma physics fusion expertise ranges from magnetohydrodynamics modelling in 3-D geometry to turbulence simulation and integrated modelling, with links into astrophysics and basic plasma physics. Atomic and molecular physics is very important in the edge regions of fusion plasmas and Australia has a long tradition of excellence in this area at a number of universities, contributing to the international database of fusion-related atomic collision data.

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Modeling of electron-atom scattering: benchmark calculations for fusion research

I. Bray, D.Fursa and A.Stelbovics
Murdoch University

Modern theoretical techniques of modeling electron scattering from atoms and ions have achieved significant success in describing various aspects of collision processes. We can now apply these techniques to model processes of interest for fusion research and obtain collision data with accuracy significantly better than 10% in most cases. Examples of electron scattering from light targets (hydrogen, helium, …) will be presented. Challenges for modeling electron collisions with heavy atoms and ions will be discussed and illustrated by some of our recent results.

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The Challenge of ITER Diagnostics

Alan E Costley
ITER International Team

The implementation of diagnostics on ITER will be a major challenge, arguably the most difficult ever undertaken in plasma diagnostics. The number and type of plasma and first wall parameters that will have to be measured will be very similar to those measured on today's large devices, but the specification of some of the measurements, such as relative spatial resolution and accuracy, will be more demanding. More measurements will be used in active feedback control, and since the tokamak will be operating close to operational limits with very high levels of stored energy, high reliability in the diagnostic systems will be essential. On the other hand, the environment of ITER will be very harsh compared to those experienced on today's machines. In-vessel components will be exposed to high levels of neutron and gamma radiation, neutron heating and particle bombardment. The flux levels will be typically 10 times higher than the maximum reached on present machines; the neutron heating will be typically 1 MW/m^3 compared to essentially zero on existing machines, but the most significant extrapolation is in the pulse length: this will be up to several thousand seconds, that is 100 times longer than that typical on present-day machines and, combined with the higher flux levels and planned high number of plasma pulses (30,000), means that the end-of-life fluence levels experienced by in-vessel diagnostic components will be more than 10^5 times higher. As a consequence, many phenomena that relate to the physical properties of materials, and how they are changed by irradiation, have to be taken into account in diagnostic design for the first time. Phenomena such as radiation induced conductivity and radiation induced EMF that can occur in cables, radiation induced absorption and radio luminescence in optical materials, erosion and deposition on mirrors, all have to be considered. This is new territory for diagnostic design and requires dedicated R&D to generate the necessary knowledge base. In parallel, the identification and development of diagnostic techniques that are better suited to the ITER environment is also needed. Since the early days of ITER, these issues have been tackled in a co-ordinated programme involving all ITER partners and a comprehensive diagnostic system is being prepared. In the presentation an overview of the system will be given and the special measures being taken to cope with the ITER environment will be described. Areas where further development is needed will be highlighted.

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Plasma diagnostics in Australia

John Howard,
Plasma Research Laboratory, Australian National University

Australia has a strong tradition of innovation in plasma diagnostics. Australian scientists have made key contributions both in the understanding of diagnostic principles, e.g. diffraction physics underpinning far-forward scattering, and in their implementation, e.g. Raman scattering calibration of Thomson scattering, LIF etc. Members of the Australian plasma physics community are frequently invited to present their work at international diagnostics symposia and regularly host international diagnostics meetings (e.g. the 7th biannual Japan-Australia diagnostics workshop was held at NIFS in December 2005).

In this talk I will review Australian diagnostics capability. In particular, I will also discuss recently developed spectroscopic coherence imaging systems. These high-throughput systems, which are now either in use, or being prepared for use at RFX (Padova, Italy), WEGA/W-7X (Greifswald, Germany), KSTAR (Daejong, Korea) and JT-60U (Naka, Japan), are suitable for a wide variety of spectroscopic tasks, including Doppler spectroscopy, MSE and polarization spectroscopy and the measurement of relative line intensity ratios. I will review these applications and discuss potential applications on ITER.

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Project Management of the OPAL Research Reactor

Greg Whitbourn
Australian Nuclear Science and Technology Organisation

This presentation outlines the project management of the OPAL Reactor from the time of funding approval in September 1997 to the present time, when performance demonstration is in progress. We will examine the purpose of the reactor, key aspects of the project management and the level of Australian participation.

Following several years of preparation of the contract specification, selection of four suitably qualified tenderers and a rigorous final selection process, ANSTO contracted an Argentine organisation, INVAP SE, as the contractor in July 2000. INVAP subcontracted an Australian entity, a joint venture between John Holland and Evans Deakin Industries (JHEDI) to provide resources in Australia. An international network of over 100 subcontractors has provided services, products and materials to INVAP and JHEDI and ANSTO has separately engaged a number of consultants and contractors to provide project support services.

The regulatory environment is complex, involving the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), the Australian Safeguards and Non-Proliferation Organisation (ASNO) and Australian security agencies, plus some inspections involving the International Atomic Energy Agency. The interaction of all these entities to establish the OPAL Reactor has been a significant networking challenge, involving a complex network of legal, contractual and functional relationships and communication processes.

OPAL will be the centre-piece of ANSTO's facilities, where our nuclear expertise supports health, environmental, industrial and national security objectives. The reactor will enhance our ability to provide high quality radiopharmaceuticals for nuclear medicine and radioisotopes for industrial and environmental applications plus neutron beams for scientific and commercial research.

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Nuclear fusion programs and ITER related work in China

Dr LUO Delong
Deputy Director General of ITER China Office

Chinese fusion research, one of the important steps towards the final utilization, has been integrated into national strategy on nuclear energy development. On the basis of the "three steps strategy", PWR, fast breeder reactor and fusion reactor, Chinese fusion research institutions/groups are strongly supported by MOST (Ministry of Science and Technology) high technology projects, CAEA (China Atomic Energy Authority) nuclear energy development projects, AS (Academy of Science) innovation foundation and NNSFC (National Nature Science Foundation Committee) nature science foundation. Therefore, some significant progress has been made during the past several years.

The ITER project, a burning plasma device and a necessary step towards the fusion reactor, integrates most achievements we have made in plasma science and fusion technologies in dozens of years. Seven parties now work hard together for ITER as a family. China government and fusion association pay a great effort on ITER activities. Chinese ITER business are supported and supervised by MOST and its office DA. 41 ITER transition arrangement (ITA) tasks are implemented, most of them are related to Chinese procurements. According to the allocation, China will contribute 10% ITER components manufacturing. Therefore, China ITER team has been doing their best on them.

There are two main institutions in China engaged in fusion research, Southwestern Institute of Physics (SWIP) and Institute of Plasma Physics (ASIPP). The programs of HL and HT are supported by CAEA and AS respectively. In SWIP, some important results, such as divertor operation, molecule beam injection, fishbone instability study, zonal flow observation, RS configuration and ITB have been made on HL-2A tokamak. In ASIPP, some results on IBW heating, long pulse operation performance have also been made on HT-7 device, meanwhile, a successful preliminary plasma operation has been completed with good performance on a newly built super-conducting tokamak EAST (HT-7U) . Apart from those mentioned above, fusion reactor design and key technology R&D are also conducted in these two institutions.

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Status of Procurement Packages of India

Prof S K Mattoo
Project Director, ITER-INDIA

ITER – India is the Domestic Agency (DA) in India charged with total responsibility of delivering and coordinating various activities related to the nine procurement packages to the ITER International Organization (ITER-IO). These include, Vacuum vessel shielding, Cryostat fabrication and assembly, Heat rejection and component cooling water systems, Cryolines and cryo-distribution components, Power sources for IC H&CD and EC H&CD start up, Diagnostic Neutral Beam (DNB), Power supplies for IC H&CD, EC H&CD start up and DNB and Diagnostics.

Various steps have been taken to create the requisite infrastructure required to ensure the delivery of these packages within the time schedule. A Core Group, staffed from the Institute for Plasma Research in ITER-India, is engaged in project planning. A number of initiatives concerning administrative and financial empowerment of the DA have been taken and are expected to be completed before March, 2007. Interaction with the Indian industry culminated into a workshop on September 29 – 30. This will be followed up by further in-depth discussions on specific topics of project execution. Some tools and equipment for design analysis (ANSYS 5.0, HYPERMESH 7.0), drawing making (CATIA V5 R16) and drawing management (SMARTEAM V5, R16) have been put in place. Initial training on the use of these tools has been provided to the scientists and engineers. Order has been placed for PRIMAVERA V5, the tool for project management.

Work plan is under formulation. Tasks for 2006 –2007 have been identified for some PPs. For the remainder, consultation process with Responsible Officers (RO) in ITER –IO is continuing. Defining scope of work, including identification of interfaces with other DAs and their domains, is receiving attention of the concerned parties (ITER-India, ITER-IO and interfacing DAs).

Required R&D and prototyping have reached advanced stage of identification for some PPs. These have been integrated in their respective execution plans. For the rest, negotiations with other DAs and internal discussions within ITER-India are underway.
A tentative proposal for the works for immediate future is given at the end of the presentation.

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The Challenges of Building a Synchrotron Based Facility in Australia

Alan Jackson
Technical Director, Australian Synchrotron

The Australian Synchrotron is a world-class synchrotron light facility being built in Metropolitan Melbourne. It is the only one of its kind in the Southern hemisphere. Technology transfer from outside the region has been a recurring theme throughout the construction and commissioning phases of the project, though we were able to find significant contributions to the technical facilities locally. Now in the commissioning phase the Australian Synchrotron has been built in record time, on budget, and with the expected performance.

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EU Fusion Technology R&D

Presented by D J Campbell on behalf of M Gasparotto
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During the ITER design activities the EU has maintained a substantial R&D programme to develop key technologies required for the construction of ITER. In recent years, major efforts have been directed towards the development of the ITER components for which procurement will be launched during the first years of the construction phase. In particular the manufacturing feasibility of the superconducting strand for the toroidal and poloidal field coils and of the toroidal field coils has been demonstrated, Studies of manufacturing techniques for the vacuum vessel, blanket modules and divertor are also in progress, and a number of EU industries have been prepared to successfully participate to the ITER construction. Substantial R&D is underway to develop technologies required for the auxiliary heating systems and for the diagnostic systems for which the EU will be responsible. In addition, a range of new test facilities will be required for testing components such as superconducting cables, remote handling technologies, auxiliary heating sources and launchers, during the ITER construction phase. Construction of several of these facilities is already underway and preparations are in hand for others. The presentation will report the main R&D activities performed in the EU and the major achievements in preparation for ITER component procurement.

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ITER-relevant materials research in Australia

D.J. O'Connor
University of Newcastle

The essential elements of the materials for ITER have been determined. For the plasma facing materials it will be carbon fibre composite, beryllium and tungsten. While these decisions are fixed for ITER there are still serious questions to be answered about how they will perform in situ. The most pressing questions relate to their response to high levels of radiation damage and to the methods of securing these components to other heat dissipating materials. These are challenges which Australian researchers are well placed to make a contribution. Furthermore there are greater challenges facing the materials to be incorporated into DEMO and research into new materials is currently both timely and topical.

Current research programs and facilities at ANSTO, CSIRO, University of New South Wales, University of Newcastle, University of Sydney, the Synchrotron and the University of Woollongong are able to meet the collective demands of Bulk Materials and Thin Film Synthesis, Characterisation, Plasma Wall interaction, Surface and Interface Analysis, Bulk and Surface Modelling and Radiation Damage Modelling. The current capabilities and future opportunities will be outlined.

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Welding and surface engineering research at University of Wollongong, and its relevance to fusion energy infrastructure

David Nolan
Department of Engineering, University of Wollongong

The expertise and facilities developed at the University of Wollongong (UOW) over the past 30 years is of direct relevance to the challenging materials research problems associated with fusion energy systems. The key aspects of materials performance of structural alloys used for the construction and maintenance of fusion reactors include weldability, resistance to high heat flux and radiation, the embrittling effects of H and He transmutation elements, and resistance to high thermomechanical loading. Further, a key factor that has not received sufficient attention to date is the consideration of weld regions in fabricated components, as these are often more structurally heterogeneous and more likely to contain detrimental transformation products or structural defects. In view of these technical challenges, UOW's considerable background in physical metallurgy, high temperature materials and welding research will be of great value to the Australian fusion materials initiative.

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Australian Space Plasma Physics and its Relevance to ITER

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Australia has world-class programs in several areas of space plasma physics, including solar and interplanetary radio emission, the coupling of Earth's magnetosphere and the Sun to the ionosphere and atmosphere, the resulting ``space weather'' effects on human technology and society, and spacecraft propulsion. Expertise exists in observation, data analysis, theoretical modelling, and the design and building of instruments and technology. A number of Australian institutions are involved, including the Australian National University, La Trobe University, the Universities of Adelaide, Newcastle, and Sydney, and IPS Radio and Space Services. This paper will review the current capabilities and research interests of Australian efforts in space plasma physics and relate them to the ITER project.

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Fusion-related dusty plasmas

S.V. Vladimirov
The University of Sydney

It has been common for a number of years that small dust particles do exist in magnetic confinement fusion devices. There are two major sets of problems related to the particle generation in fusion devices: one is related to the safety of operation of the fusion reactor, and the other is related to the plasma parameters and stability. The main challenges with respect to dust in fusion devices (including ITER) are: processes of dust formation; physical properties of the dust formed; dust dynamics, transport and interactions with the fusion plasma and walls; consequences of the dust contamination.
The size of dust particles in fusion devices varies in broad ranges, from a few tens of nanometres to several millimetres. The dust composition is mostly carbon but may also include all other materials used inside the vessel or for wall conditioning purposes. Dusts in a plasma are charged, e.g., by collecting electrons and ions, and this charge can be extremely high (e.g., 10^3 - 10^4 electron charges for a micron-sized particle). This prompts strong interaction of particles leading to self-organization and structure formation.
The Complex Plasma Group (including also the Complex Plasma Laboratory) at the School of Physics, University of Sydney, has established a number of research activities in the field of multi-component impurity-containing plasmas ("complex dusty plasmas"). The current research is concentrated on several directions: the dynamics and transport of dust in the plasma sheath and near walls, formation and properties of dust, and influence of dust on collective plasma processes. These activities also involve extensive international collaborations, in particular with parties directly involved in ITE such as: EU, Japan, Russia, USA, as well as with parties wishing to join ITER such as Brazil.

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Canadian Fusion Energy Initiative – A continuation of fusion research in Canada

Claude Boucher
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Canadian scientists and engineers have been engaged in fusion research for decades, in particular as participants in the Canadian National Fusion Program, started in the early 1980's. Since its cancellation in 1997 for global budgetary reasons, four Canadian universities have nevertheless maintained several fusion research projects, to a large extent by exploiting the strong links to the fusion world effort via international collaborations. These institutions, University of Saskatchewan, Institut national de la recherche scientifique (INRS), University of Toronto Institute of Aerospace Studies (UTIAS), and University of Alberta, have decided to propose a Canadian Fusion Energy Initiative (CFEI). The CFEI seeks to establish a scientific research program in fusion energy development targeted at ITER, with the objective of contributing at the forefront of research in this field and thereby gaining access to ITER-developed know-how and intellectual property. The Canadian context will be recalled, the ongoing fusion related activities will be summarised and potential Canadian involvement in ITER will be presented.

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Thursday, October 12, 2006	
8:20 am to 8:40 am	Workshop opening, **Chief Scientist of Australia, Prof Jim Peacock**
Session 1	**Chair: Prof J O'Connor (University of Newcastle)**
8:40 am to 9:20 am	**Dr D Gambier** Overview of the ITER program and current status
9:20 am to 9:50 am	**Dr M Hole** Fusion energy for future generations: The case for an Australian involvement in the ITER program
9:50 am to 10:20 am	**Dr D Campbell,** Key ITER physics issues
10:20 am to 10:40 am	Morning tea
Session 2	**Chair: Prof A Cheetham (Canberra University)**
10:40 am to 11:10 am	**Dr M Mori**, Status of ITER Technical Activities in Japan
11:10 am to 11:35 pm	**Dr B Blackwell,** H-1NF: The National Plasma Fusion Research Facility
11:35 pm to 12:05 pm	**Prof N Sauthoff** Status of ITER Technical Activities in the USA
12:05 pm to 12:30 pm	**Prof B James,** Plasma physics at the University of Sydney
12:30 pm to 1:30 pm	Lunch
Session 3	**Chair: Dr B Blackwell (Australian National University)**
1:30 pm to 2:00 pm	**Dr S Itakura**, ITER and the Broader Approach Program
2:00 pm to 2:30 pm	**Dr S Clement-Lorenzo**, EU Accompanying Program to ITER
2:30 pm to 2:55 pm	**Prof R Dewar,** Plasma theory and modeling in Australia
2:55 pm to 3:20 pm	**Dr D Fursa,** Modeling of electron-atom scattering: benchmark calculations for fusion research
3:20 pm to 3:50 pm	Afternoon tea
Session 4	**Chair: Prof B James (University of Sydney)**
3:50 pm to 4:20 pm	**Dr A Costley,** ITER diagnostics
4:20 pm to 4:45 pm	**Dr J Howard,** Australian diagnostics systems and expertise
4:45 pm to 7:00 pm	Break
7:00 pm to 11:00 pm	Dinner

Friday, October 13, 2006	
8:45 am to 8:50 am	**Announcements**
Session 5	**Chair: Dr M Hole (Australian National University)**
8:50 am to 9:20 am	**G Whitbourn,** Project Management of the OPAL Research Reactor
9:20 am to 9:50 am	**Prof LUO Delong**, Nuclear fusion programs and ITER related work in China
9:50 am to 10:20 am	**Prof S Mattoo**, Status of Procurement Packages of India
10:20 am to 10:40 am	Morning tea
Session 6	**Chair: Dr G Collins (Australian Nuclear Science and Technology Organisation)**
10:40 am to 11:10 am	**Prof A Jackson**, The Challenges of Building a Synchrotron Based Facility in Australia
11:10 am to 11:40 am	**Dr D Campbell,** EU Fusion Technology R&D
11:40 am to 12:05 pm	**Prof J O'Connor,** ITER-relevant materials research in Australia
12:05 pm to 12:30 pm	**Dr D Nolan**, Welding and surface engineering research at University of Wollongong, and its relevance to fusion energy infrastructure
12:30 pm to 2:00 pm	Lunch.
Session 7	**Chair: Dr J. Howard (Australian National University)**
2:00 pm to 2:25 pm	**Prof I Cairns,** Australian space plasma physics and its relevance to ITER
2:25 pm to 2:50 pm	**Prof S Vladimirov,** Complex plasma research in Australia
2:50 pm to 3:20 pm	**Prof C Boucher,** Canadian Fusion Energy Initiative – A continuation of fusion research in Canada
3:20 pm to 3:45 pm	Afternoon tea
3:45 pm to 4:45 pm	**Panel discussion (Tim Dean moderator) and concluding remarks**