1st Technology in Inertial Fusion Workshop

28th September 2010 – Oporto Portugal
Satellite Meeting of SOFT 2010
http://soft2010.ipfn.ist.utl.pt/

Registration

http://registrations.ipfn.ist.utl.pt/satellite/

Fee: 20€

Programme Tuesday 28th September 13h30 – 18h00

13h30 – 13h50	Opening
13h50 – 14h20	F Kovacs (CEA-Cadarache, France) "Convergent technological approaches between IFE and MFE facilities"
14h20 – 14h50	J Ebrardt (CEA, France) "Fusion with the LMJ"
14h50 – 15h20	K Mima (Osaka, Japan) "Status and prospects of fast ignition laser fusion with FIREX"
15h20 – 15h50	R B Stephens (GA, US) "IFE technology at GA"
15h50 – 16h20	Break
16h20 – 16h50	A Bret (Ciudad Real, Spain) "Fusion, Energy, Climate: a Broad Perspective"
16h50 – 17h20	J Pasley (York, UK) "Investigating neutronics and materials issues for Inertial Fusion Energy reactors"
17h20 – 17h50	M Perlado (Madrid, Spain) "Materials research for HiPER laser fusion facilities: chamber wall, blanket, structural material and final optics"
17h50 – 18h00	Closing

Note: Wednesday 29th September

09h10 – 09h50	V Tikhonchuk (Bordeaux, France) "Alternative schemes for the inertial fusion energy"

ABSTRACTS

Convergent technological approaches between IFE and MFE facilities

Dr. Francis KOVACS
Deputy Director of CEA-Cadarache

The talk will focus on IFE and MFE common functions of a system approach in order to point out where the two communities can meet fruitful collaborations: system engineering, functional analysis and economical optimization, material damages to radiation, hardening techniques, instrumentation, tritium management and safety, system acquisition and control, nuclear waste, vacuum chamber and heat extraction, environmental aspects, societal acceptance…are many examples of domains shared by the global fusion community.
ITER and LMJ will illustrate the presentation with real cases among the above topics.

Fusion with the LMJ

Jacques Ebrardt
CEA/DAM Île de France

The Laser Mégajoule (LMJ) is under construction by the French Commissariat à l'Energie Atomique (CEA) at CESTA laboratory near Bordeaux. The LMJ is an important part of the French "Simulation Program". The LMJ is designed to deliver about 1.8 MJ of ultraviolet light on target for high energy density physics. It is designed to obtain ignition and fusion of a DT fuel capsule.
Achieving fusion with LMJ requires a coordinated program associating the facility itself, as well as optimized fusion targets, plasma diagnostics, and simulation tools. We identified a large variety of fusion targets that require no more than 1.4 MJ of laser energy, offering a path to fusion and new opportunities for operating LMJ. Some aspects of this overall program are presented.
Civil works have been completed and the building was commissioned in December 2008. The laser bundles assemblies of the amplifying section are being installed, as well as the mechanical frameworks around the target chamber. The current status of the LMJ project is presented.

Status and Prospects of Fast Ignition Laser Fusion with FIREX

Kunioki Mima[1,2,3], M.Perlado[1] and H.Azechi[3]
[1]*Institute of Nuclear Fusion, Universidad Politecnica de Madrid, Madrid, Spain*
[2]*Institute of Laser Engineering, Osaka University, Osaka, and The Graduate School for the Creation of Advanced Photonics Industries, Hamamatsu, Japan*
[3]*Institute of Laser Engineering, Osaka University, Japan*

Inertial Fusion Energy (IFE) research started in 1960's and developed together with the high power laser technology. The key issues of IFE are driver laser, target design and fabrication, and ignition physics. In the laser IFE (laser fusion), the fusion gain defined by (Fusion out put)/ (input driver energy) is required to be 100 because of limited efficiencies of laser and low coupling efficiency between laser and imploded plasma internal energy. Therefore, plasma confinement parameter: product of plasma density and radius is required to be higher than $3g/cm^2$. In order to realize such a high area density with reasonable laser energy, the plasma should be compressed to be higher than 1000 timed solid density of DT. Furthermore for the high gain, the imploded main DT fuel temperature should be in low isentrope and it is necessary to form a hot spark from where fusion burn wave propagates into the main fuel. The several ignition schemes have been proposed, which are the central ignition with adiabatic heating or spherical shock heating and off-center ignition with instantaneous heating with a ultra-intense laser beam or a high density and high velocity impactor.

In the central adiabatic spark ignition, laser pulse energy for the high gain is required to be higher than 1.5MJ or more. On the other hand, in the advanced ignition, the high gain could be achieved with a relatively compact laser, say, with the laser energy of lower than 1MJ. In the year of 2011, ignition with 1.8 MJ/0.35 μm pulse of NIF will be demonstrated by the National Ignition Campaign (NIC) at Lawrence Livermore National Laboratory (LLNL). After the success of NIC at LLNL, high gain experiments with direct drive implosion and fast ignition experiments will follow. The fast ignition realization experiment-I (FIREX-I) started in 2004 at ILE,Osaka. By this project, the feasibility of fast ignition will be clarified in the next year. The most important key issues of fast ignition is the heating efficiency of the imploded plasma. The high heating efficiency with an advanced target will be demonstrated.

After the ignition demonstration, high repletion rate high gain facilities will follow toward IFE DEMO reactor. The critical issues for R&D of IFE-DEMO will be plasma wall interaction, neutron damage on final optics, chamber conditioning, target fabrication and supply, plasma facing material, and so on. Those R&D are now starting in relation with HiPER project in EU, LIFE project at LLNL, and LIFT project in Japan.

In this talk, status and prospects on the above researches will be presented.

IFE Technology at GA

R.B. Stephens

General Atomics, San Diego, CA, USA

In previous years General Atomics has been involved with all prominent approaches to Inertial Fusion Energy (IFE), including laser driven fusion, heavy ion driven fusion, and Z-pinch based fusion energy. GA's role in these IFE programs has focused primarily on the target technology, including the entire target supply chain ranging from target manufacture to target injection, tracking, and engagement. This role has logically leveraged off our much larger target fabrication contract for the US national ICF program. While there is currently very limited IFE funding from the US Department of Energy for inertial fusion, IFE target technology work continues at GA on internal funding, with our effort refocused to a nearer term step on the "pathway to IFE" - Targets and insertion systems appropriate for the new generation of powerful rep-rated lasers that are now coming on line. Their need for complex targets, and their ability to shoot at >1/min require substantial improvement in throughput and productivity (with resulting reduction in cost per target) and in much faster target insertion and alignment than previously existed. Our activities under this program will be discussed. They include:

1) mass production techniques for 3-D components

2) automated (robotic) assembly of complex targets
3) injection of targets (also developed for magnetic fusion applications)
4) target tracking and driver beam engagement systems.
Components of this work have been utilized in equipment installed and a campaign at the Gemini-Astra laser at Rutherford Appleton Laboratory in the UK. This work was performed with Neil Alexander, Dan Frey, Dan Goodin, Gary Lee in the IFE group at General Atomics.

Investigating neutronics and materials issues for Inertial Fusion Energy reactors

John Pasley[1,2], Lee Morgan[1] and Christopher Fury[1]
[1]*Department of Physics, University of York*
Kate Lancaster[2] and Rob Clarke[2]
[2]*STFC Rutherford Appleton Laboratory, Central Laser Facility*
Raul Pampin-Garcia[3] and Lee Packer[3]
[3]*Neutronics and Nuclear Data Group, Culham Centre for Fusion Energy*

The Department of Physics at the University of York has launched a new initiative to investigate inertial fusion energy reactor physics, building upon its existing programme in Inertial Fusion Target Physics. With involvement from both the Central Laser Facility and the Culham Centre for Fusion Energy, we aim to strengthen ties between the inertial and magnetic fusion energy communities and exploit areas of commonality between the two fields. Our major focus at present is the neutronics of inertial fusion reactors which concerns both the breeding of tritium and other materials in the blanket as well as the degradation of reactor components in the intense neutron flux. The problem differs somewhat from that in magnetic confinement fusion, in both the nature of the source (pulsed high intensity versus lower constant intensity) and the nature of the components that will be exposed. Modifications to the codes used in MFE research are required to take into account some of the differences, and this is one area in which we are currently working. Some of the first results of this work will be presented. In addition we have started developing experimental techniques for testing the susceptibility of both existing and new optical component materials; this research will also be discussed.

Fusion, Energy, Climate: a Broad Perspective

A. Bret
Universidad Castilla La Mancha, ETSI Industriales, Avda Camillo Jose Cela, s/n, 13 071 Ciudad Real, SPAIN

Like any finite quantity resource, oil will run out sooner or later. The so-called "peak-oil" will not necessarily bring an end to the fossil fuels era as coal reserves are still abundant (though not infinite). Meanwhile, fossil fuels combustion is emitting greenhouse gases which impact on global climate is now detectable. This talk will review the orders of magnitude involved, the time scales connected to each issue, and the possible role of thermonuclear fusion in the energy/climate equation.

Materials research for HiPER laser fusion facilities: chamber wall, blanket, structural material and final optics

J. Alvarez, A. Rivera, R. González-Arrabal, D. Garoz, E. del Río, F. Ognissanto, R. Juarez, J. Sanz, J.M. Perlado
Instituto de Fusión Nuclear (UPM), Madrid, Spain
antonio.rivera.mena@gmail.com

The European inertial fusion project, HiPER (High Power laser Energy Research facility) is now in the final year of the preparatory phase. The goal is to build a facility for repetitive laser operation (HiPER 4a) working with bunches of 100 shots with up to 5 ignition shots and a maximum energy per bunch of about 100 MJ. Next, (circa 5 years later) a reactor to demonstrate commercial viability of inertial fusion energy (IFE) will be built. Thus, it will have to operate continuously at full power producing its own tritium and generating electric power. Over the next 7 years, a technological phase will take place to minimize construction risks through appropriate R&D activities. Currently, there are several potential solutions for chamber, blanket and reactor systems that will be downselected over the next years based on R&D activities undergone by HiPER and other IFE projects, remarkably, NIF, LIFE programs in the USA, and LIFT in Japan.
The ignition scheme is not decided yet but it is desirable to keep open Fast Ignition (FI) and Shock Ignition (SI) as first option, which favors the use of dry wall chambers with no gas protection. Options such as direct drive (DD) and indirect drive (ID) targets are open for future discussion. For the case of fast ignition (or shock ignition) schemes, similar to DD, with target yields exceeding 100 MJ, there are no first wall materials appropriate to withstand the fusion event at distances of about 5-6 m. This is due to fatal thermo-mechanical effects such as cracking and melting and defect-driven effects, e.g., exfoliation of W through He nucleation in cavities. The most successful solution for the first wall would be to find materials (i) with large surface area (i.e., needle like structures) to deposit the energy over larger volumes, so that thermo-mechanical effects can be mitigated and in addition facilitate light species release; (ii) self-healing materials (e.g. nanocrystals) to minimize defect-induced undesired effects. In this paper we will describe the work in progress under the framework of HiPER in close collaboration with the Magnetic Fusion community efforts to find appropriate materials for the divertor region.
Structural materials (and final optics) will be subjected to high fluxes of neutrons leading to loss of mechanical (and optical) properties and other deleterious effects, remarkably, swelling. Within the framework of HiPER we are carrying out R&D activities on (i) nanostructured materials development to promote material self-healing, (ii) materials modeling (silica, nano-materials and steels), (iii) reproducing experimentally IFE neutron irradiation conditions, by means of triple beam accelerators and neutron facilities. Whilst pertinent to IFE, these material developments also satisfy issues arising in Magnetic Fusion and Gen IV projects. The status of these activities and significant results will be discussed in the paper.