C16 report to the 2008 General Assembly for the period 2006-2008

Tsukuba, Japan

October 15-17, 2008

1. Commission Activities

The major aim of the Commission on Plasma Physics (C16) is the

- The promotion of exchange of information and views between the members of the international scientific community in the area of Plasma Physics, which encompasses such widely different domains as nuclear fusion research, astrophysics and space plasmas, plasma based accelerators, industrial plasmas and fundamental plasma sciences.
- To recommend international conferences for IUPAP support
- To promote the free circulation of plasma scientists.

In keeping with this mission, C-16 developed the following activities:

The Commission had three formal meetings each on the occasion of one of the two major conferences sponsored by C16. These were the 13th and 14th International Congress on Plasma Physics, held at Kiev, Ukraine (May 22-26, 2006) and at Fukuoka, Japan (September 8-12, 2008), and at the 18th International Conference on Phenomena in Ionized Gases held at Prague, Czech Republic (July 15-20, 2007). In addition, the members had frequent and fruitful mail exchanges.

These two regular biennial conferences allow following major advances in the full plasma physics activity indicated in the introduction. The ICPIG conference is also seen by C-16 as a good occasion for promoting interaction with industries involved in plasma applications. C-16 further supports individual meetings, particularly in the field of research areas of developing interest. This was the case, in the present reference period, with the International Conference on the Physics of Dusty Plasmas, Azores, Portugal, May 18-23, 2008.

An important task and perceived asset in the Commission work is the institution by IUPAP of the Young Scientist Prize in Plasma Physics. C-16 decided to alternate the award on a two year basis between cold and hot plasmas, stemming from its desire to link the award specifically and alternatively to the IUPAP sponsored conferences ICPIG and ICPP and to bestow the award on the occasion of these conferences. The response of the community to this new prize was extremely gratifying. In 2007, the prize went to Dr Pascal Chabert of Ecole Polytechnique, Paris for having made important contributions to the understanding of plasmas and plasma sources used in plasma processing, especially in connection with the physical size increase of the processors currently used commercially. The 2008 prizewinner was Dr Michael Van Zeeland of General Atomic, San Diego, who demonstrated excellent skills in all aspects of experimental work, allowing him to produce important work on the generation of Alfvén waves, on the diagnosis of Alfvén instabilities in fusion plasmas, and on the comparison of Alfvén instabilities with theoretical predictions.

The commission continued to make conscious efforts to involve scientists from less privileged countries to its plasma physics conferences. The scheduled organization of ICPIG 2009 in Mexico and of ICPP 2010 in Chile is a further endeavor in this direction. C-16 also insisted on a true internationalisation of the Programme Committees of its sponsored conferences.

2. Some major advances in Plasma Physics

A very comprehensive overview of the widely diverse activities, mentioned in the introduction and that have developed around plasma physics over the last decades, can be found in our 2005 report. The present report points to some recent advances and has no claim of completeness in this ever-flourishing field. The interested reader is referred to the websites of the two recent C16 sponsored conferences (http://icpig2007.ipp.cas.cz/, www.triam.kyushu-u.ac.jp/ICPP) for a more complete update.

In 2008, the fiftieth anniversary of the declassification of **fusion research** is celebrated. The 22nd IAEA Fusion Energy Conference is held from October 13-18 in Geneva to commemorate this event under the heading “Celebrating fifty years of fusion…entering into the burning plasma era” and will provide an ideal forum for judging the continuing progress in this field. The most important development in Magnetic Confinement (MCF) research was the signing on 21 November 21, 2006, by China, the EU, Japan, India, Korea, Russia and the USA, of the Joint Implementation Agreement establishing the international ITER Organization. By the construction of the International Tokamak Experimental Reactor (ITER) at Cadarache, France, the scientific and technological feasibility of fusion power for peaceful purposes by can really commence in truly burning plasma conditions. In Inertial Confinement fusion (ICF) both the National Ignition Facility (NIF, Livermore, USA) and the Laser MEGAJOULE (LMJ) are progressing well in their construction. The full 192 laser beams of NIFS are expected to be completed in March 2009 and should deposit 1.8 MJ on the hohlraum targets. The same amount of power from 240 beams should be available in the French devices in 2010. The novel so-called fast ignition scheme, in which a short pulse secondary laser gains access to the core of a target compressed by a primary driver through a reentrant cone, is under intense investigation and is expected to significantly lower the energy requirements of ICF.

Exciting developments are taking place in the area of **plasma based charged particle acceleration**. A laser or charged particle beam creates an electron plasma wakefield due to the ponderomotive force of intense laser beams or the driving force of electron beams. The plasma wakefield has a phase speed close to the speed of light, and the acceleration gradients in the plasma wakefield can easily exceed those achieved in conventional radio-frequency technology. As such, a UCLA team achieved in 2007 at the Stanford linear Accelerator Center an accelerating electric field of 52 GV/m in a plasma wakefield accelerator and sustained it for 85 cm, thus producing about the same energy gain as the 3-km long SLAC accelerator, albeit for a relatively small number of electrons (Nature 445, 741-744, 2007). Besides their attractiveness for moving the energy frontier of particle physics, the plasma-based systems are also attractive as potential radiation sources for ultra-fast time resolved studies in biology and physics.

The **industrial** application of plasmas is still seen to grow in an explosive manner, as reported in the C-16 report of 2005. A relative, but rapidly catching up, newcomer, is the field of **medical plasma applications**. In the so-called plasma medicine, new types of non-thermal plasmas are used for tissue sterilization and treatment of wounds, of skin and other diseases. In plasma biotechnology, plasma is increasingly used as a catalyst of many natural biological processes, enabling e.g. deactivation of viruses and bacteria in buildings, medical equipment, food, etc. where more traditional methods fail.

Laboratory astrophysics is one of the youngest branches of astrophysics. Whereas its name was coined about 30 years ago in order to denote the investigation of the solid phases in astrophysical environments by laboratory simulation experiments, this new field has developed today into a intense multidisciplinary effort where a whole gamut of astrophysical phenomena are studied in the laboratory: extreme matters of state, auroral radiation emission, momentum transfer in accretion discs, collimated plasma jets, radiative shocks, etc..

Whereas some 15 years ago scientific interest in **dusty plasmas** was motivated mostly by the needs of the microelectronics industry, the observation that such particles can organize themselves into crystal-like structures opened the door to spectacular developments in controlled crystal growth, such as the synthesis of thin films for solar-cell applications. More recently, a natural self-organization into stable interacting helical structures that exhibit features normally attributed to organic living attracted a lot of attention (New J. Phys. 9 (2007) 263).