IUPAP C.16 report to the 2011 General Assembly for the period 2008-2011

London, United Kingdom

October 31- November 4, 2011

Commission Activities

The major aim of the IUPAP Commission on Plasma Physics (C.16) is

- 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 charged particle accelerators, low-temperature industrial plasmas and fundamental plasma sciences.
- to recommend international conferences for IUPAP support
- to promote the free circulation of plasma physicists acroos the globe.

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

The C.16 had three formal business meetings each on the occasion of two major plasma physics conferences sponsored by C16. These were the International Conference on Phenomena in Ionized Gases (ICPIG), held in Cancun, Mexico (12-17 July 2009), the 15th International Congress on Plasma Physics (ICPP), held in Santigao de Chile, Chile (August 8- 13, 2010), the 30th International Conference on Phenomena in Ionized Gases (ICPIG), held in Belfast, UK(28th August-2nd September 2011 July). In addition, C.16 members (both regular and associate) had frequent and fruitful e-mail exchanges, and discussions at other meetings (e.g. 6th International Conference on the Physics of Dusty Plasma, held in Garmisch-Partenkirchen, Germany, 16-20 May 2011, sponsored by IUPAP as a catergory B conference) for improving the visibility of C.16 at international scales.

These two regular biennial conferences (e.g. ICPIG and ICPP) allow following major advances in the plasma physics activities that are indicated in the introduction. The ICPIG is regarded by C.16 as a good plateform for promoting interactions with industries involved with the applications (e.g. the plasma medicine, nanotechnolgy by means of dusty plasmas, etc.) of low-temperature plasmas. Furthermore, C.16 also supported small-scale meetings, particularly in the emerging areas of plasma physics that are interdisciplinary and have potential applications in space and laboratory.
In this regard, we supported the 6th International Conference on the Physics of Dusty Plasmas (ICPDP), Garmisch-Partenkirchen, Germany, May 16-20, 2011, and International Topical Conference on Plasma Science (ITCPS): Strongly Coupled Ultra-Cold and Quantum Plasmas, Lisbon, Portugal, 12-14 September 2011.

An important task and perceived asset in the Commission work is the institution by IUPAP of the Young Scientist Prize (YSP) in Plasma Physics. C.16 decided to alternate the award on a two year basis between the low-temperature and high temperature plasmas, stemming from its desire to link the award specifically and alternatively to the IUPAP sponsored conferences (viz. 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. The IUPAP C.16 YSP reciepients were Dr Pascal Chabert (2007) of Ecole Polytechnique, Paris, Dr. Michael van Zeeland (2008) of General Atomics, San Diego, USA, Dr. Timo Gans (2009) of Queen's University of Belfast, UK, Dr. Matthiew Hole (2010) of ANU, Australia, and Dr. Iliya Dodin (2011) of Princeton University, USA for their significant contributions to low-and high temperature plasma physics in the early stage of their scientific career.

The IUPAP C.16 continued to make major efforts to involve scientists from less favored countries and female plasma physicists across the globe to its international plasma physics conferences (viz. ICPIG, ICPP, ICPDP). The scheduled organization of of ICPP 2012 in Stockholm is a further endeavor in this direction. C.16 also insisted on a true internationalization of the Programme Committees of its sponsored conferences.

Highlights of Some Major Advances in Plasma Physics

There are two major activities centered around the fusion plasma physics and fundamental plasma physics relevant for space and industrial applications. In the area of fusion plasma physics, two approaches involving the magnetically confinement fusion (MCF) and inertial confinement fusion (ICF) schemes are under serious considerations. Over the years, tremendous progress has been made in both MCF and ICF areas. The International Tokamak Experimental Reactor (ITER) project deals with MCF burning plasmas, while ICF is using multiple (192 at National Ignition Facility at LLNL Livermore, and 240 in Laser Facility in France) powerful laser beams for fast igntion and for fusion power production.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. Besides, there are alternative concepts for producing fusion energy through magnetoinertial confined divices (MCD) and Stellerators.

In 2008, the fiftieth anniversary of the declassification of **fusion research** was 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

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 ITER at Cadarache, France, the scientific and technological feasibility of fusion power for peaceful purposes can really commence under truly burning plasma conditions.

There have been exciting developments in the areas of plasma based charged particle acceleration and exploring new horizons of exotic high-density plasma physics in the quantum regime (e.g. applications of quantum plasma physics for quantum free electrons lasers at nanoscales) involving intense short laser pulses or charged particle beams. One is thus aiming to push the frontiers of high energy particle physics by accelerting electrons, positrons and protons by high-gradient space charge electric field that are created by the ponderomotive force of intense laser beams or the driving force of electron beams. By using the SLAC facility at the University of Stanford, a team of plasma physicists at UCLA has demonstrated the acceleration of electrons upto 100 GeV by the wakefield concept. Furthermore, lasma physicists in the USA, Europe, Japan and China are developing techniques for creating monoenegetic proton beams of high energies (say upto 150 MeV). Such proton beams are required for medical purposes (e.g. the treatment of cancer). 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. Finally, intense laser beams are also used for modelling numerous astrophysical pheneomena (e.g. radiative shocks, collimated plasma jets, transport of angular momentum in accretion disks) by designing and conducting new laboratory experiments and also by using advanced 3D computer simulations.

The **industrial** applications of plasmas is still growing in an explosive manner. A relative, but rapidly catching up, newcomer, is the field of **medical plasma science**. 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.

Whereas some 20 years ago scientific interest in low-temperature **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. Dusty plasmas are of great interest in the context of the formation of planets, as well as in understanding dust-plasma interactions in our solar system, including the Martian environments, moon, and the near-Earth atomospheres (e.g. the polar mesosphere and the lower ionosphere). Thus, new studies with an external magnetic field are under intense consideration. More recently, there emerges a new field of ultracold neutral plasmas that have potential applications for ion sources (e.g. ion milling), ion microscopy, and seeding free electron lasers.