ÉCOLE POLYTECHNIQUE
ParisTech

Press release

Boiling the Vacuum

Eminent physicists from around the world will gather in Glasgow this month at a conference hosted by the University of Strathclyde to explore new ways of investigating the fundamental structure of matter and vacuum through the use of the highest power lasers available, which is leading to a new paradigm in basic physics research.

Conference hosted by the University of Strathclyde, Glasgow, in November

A diverse group of physicists from many disciplines of science will meet at the University of Strathclyde, Glasgow, from November 13, 2012 to November 15, 2012, to explore the possibility of using ultra intense lasers as powerful new tools to investigate the basic structure of vacuum and matter. By going beyond what is possible with today's conventional accelerators they plan to open out a host of new opportunities. This challenging goal, at a time when we celebrate the 50th anniversary of the laser, musters the major laser laboratories around the world in a quest to produce laser beams with peak powers in the exawatt-zettawatt regime, with pulse durations in the attosecond to zeptosecond range. Peter Higgs, who proposed the "Higgs Boson", recently observed at CERN, will give a keynote talk at the Conference.

IZEST (International centre of Zetta-Exawatt Science and Technology)

Twenty-seven associated laboratories across 13 countries are part of this international programme known as IZEST (International centre of Zetta-Exawatt Science and Technology), which has been initiated and coordinated by the École Polytechique and the CEA. The power that the researchers need to reach is hundreds of millions to billions of times the worldwide energy consumption rate, but over an extremely short time measured in femtoseconds (10^{-15}s), attoseconds (10^{-18}s) or even zeptoseconds (10^{-21}s). When tightly focused, the huge intensity obtained will make the vacuum boil: fundamental particles that are usually hidden from view will spontaneously pop out of the vacuum to become a unique and very exotic gas of fundamental particles that can be studied by leading scientists from around the world. As a first step to reach these intensities the scientists will use the PETAL laser, near Bordeaux, France, and then secondly, large scale lasers such as the LMJ or the NIF. The mission of the Conference is to point out complementary alternatives to today's conventional accelerator based technology. PETAL is the property of Aquitaine, a partner in the IZEST project and conference.

High energy physics: a new paradigm

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High energy physicists explore fundamental questions on the nature of the universe, such as the fundamental particles that constitute space and all matter, and its origin and structure. These investigations are part of a long tradition that stretches back to the Greek Philosophers. In their pursuit of new particles, High Energy Particle physicists utilise large scale accelerators, such as the LHC at CERN, to produce high energy particles which they collide together to investigate their structure and also to give a glimpse into the nature of all matter. Data from these experiments are helping to place the jigsaw pieces of theories for a comprehensive understanding of our universe – and they drive the new revolutions in our understanding of it.

The ubiquitous laser, which is just over 50, is driving a scientific revolution that is now spilling over into basic physics research. Laser technology has developed to the point where we can now contemplate using lasers as tools of a new paradigm that is complementary to the current use of conventional high energy accelerators. Laser-driven particle accelerators utilise plasma (fully ionised gas) to accelerate particles to high energies in distances that are 10,000 times shorter than using conventional accelerator technology. This makes them very compact and, in principle, enables the maximum particle energy to be substantially increased. For instance it could be possible to accelerate particles to the PeV energies relevant to astrophysics. Current technologies would require an accelerator that would girdle the earth (40,000km) – but with laser acceleration, the same particle energy could be obtained over a mere kilometre.

This possibility offers astrophysicists the prospect of producing and studying high energy particles on earth that are usually only found in space. In addition, the bursts of particles provided by the laser will be extremely short, on the atto-zepto second scale and could simulate over short distances, i.e. 1 km or so, gamma rays or high energy particle bursts crossing the entire universe.

Focusing these extremely high power lasers to a very small diameter spot produces extremely high intensities, much higher than has been possible before, which allows basic questions of the fundamental structure of matter and the vacuum to be investigated directly with lasers – this is the new paradigm.

New societal applications

The possibility of accelerating particles using ultra-compact accelerators also has important potential societal applications, notably in medicine with isotope production and particle radiotherapy, as well as in nuclear waste imaging and treatment where isotope longevity can be reduced from a few hundred thousand years to in some cases minutes. Delegates will also hear how ultra-compact x-ray free-electron lasers can be constructed using laser-based accelerators – which will allow holograms of large molecules relevant to many industries to be produced. However, some of these applications

will require very efficient lasers – so one important aspect of the Conference is exploring new laser technologies and how laser beams can be manipulated to make them suitable for applications. A full day during the conference will be dedicated to these very important societal applications.

Quotes

Gerard Mourou, director of IZEST, says of the laser: "The materialization of light through the vacuum has been one of the Holy Grails of the laser since its inception 52 years ago."

Gerard Mourou, director of IZEST, says: "IZEST program is ingenious because it will avoid building an expensive new laser system but rather adapt existing large-scale laser built for fusion like PETAL, LMJ in France and NIF in California."
Gerard Mourou, director of IZEST, says: "It is the first time that the laser international community teams up to address one ambitious common scientific goal like the High Energy Physicists with the search for the Higgs boson for instance."

Toshi Tajima, Chair of ICUIL and Deputy Director of IZEST, says: "IZEST accesses the highest intensity of frontier science that International Committee for Ultrahigh Intensity Lasers (ICUIL) champions."

Toshi Tajima, Chair of ICUIL and Deputy Director of IZEST, says: "We welcome the confluence of two important branches of contemporary science, laser and high energy, through IZEST."

Toshi Tajima, Chair of ICUIL and Deputy Director of IZEST, says: "IZEST not only pushes the boundary of laser-driven high energy physics further, but also opens up new paths toward it."

Dino Jaroszynski, director of SCAPA, says: "Laser-driven accelerators are poised to drive a revolution in the way physics is done. Because of their compactness they could be situated in numerous university-sized institutes and made widely available."

Dino Jaroszynski, director of SCAPA, says on medical applications: "Radio-therapy for cancer and medical imaging are the most important immediate applications that we are working on at Strathclyde."

Dino Jaroszynski, director of SCAPA, says on applications: "An ultra-compact X-ray free-electron laser driven by a laser-plasma accelerator is a dream that we plan to turn into reality."

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About the University of Strathclyde

The University of Strathclyde in Glasgow was founded in 1796. As a place of useful learning, we take it as our responsibility to research, teach and be of direct benefit to society, reaching outside the University to make the world better educated, more prosperous, more secure, fairer and healthier. Find out more at www.strath.ac.uk
The Scottish Centre for the Application of Plasma Based Accelerators, SCAPA, is a new Centre of Excellence that brings together Scottish Scientists and their collaborators to apply laser-plasma based accelerators in useful ways.

About the École Polytechnique

Widely internationalized (30% of the student body, 23% of faculty members), École Polytechnique combines research, education and innovation at the highest scientific and technological level. Its three degree programs – ingénieur polytechnicien, Master's and PhD – are highly selective and promote a culture of excellence with a strong emphasis on science, combined with humanist traditions.
École Polytechnique educates responsible men and women who are prepared to lead complex and innovative activities which respond to the challenges of 21st century society. With its 21 laboratories, all joint research facilities with the National Center for Scientific Research (CNRS), the École Polytechnique Research Center works to expand the frontiers of knowledge in the major interdisciplinary issues facing science, technology and society.
As a ParisTech member institute, École Polytechnique is also one of the driving forces behind the Paris Saclay Campus project, along with its 22 academic and scientific partners.
http://www.polytechnique.edu

About the CEA

CEA is a French government-funded technological research organisation, a prominent player in the European Research Area. It intervenes in the field of low carbon energy, defense and security, health and information technologies.
http://www.cea.fr