UK news from CERN

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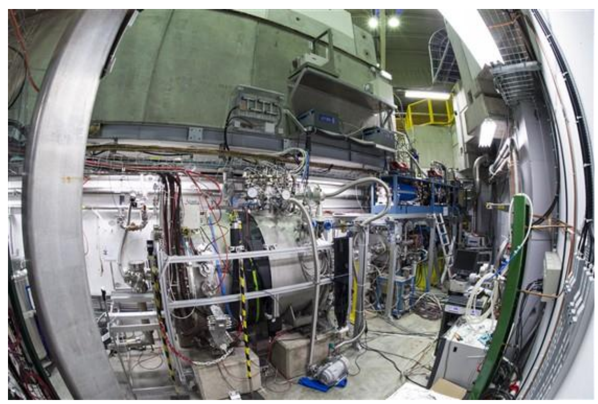
Quantum magic

Imagine being able to 'inflate' an atom with a laser, then slow it down, catch it or bend it around corners. Stephen Hogan (University College London) is applying his unusual skills to a CERN experiment that is aiming to find out whether antihydrogen falls with the same acceleration as hydrogen.

Stephen, who has recently moved to UCL from ETH Zurich, has been involved with the AEgIS collaboration since 2006. Based in CERN's Antiproton Decelerator, AEgIS is designed to test whether antimatter complies with the weak equivalence principle (WEP). The WEP states that the acceleration experienced by a particle in a gravitational field is independent of its mass and composition. It has been tested with very high precision for matter, but never for antimatter. If the results of the experiment show that the gravitational acceleration of antimatter in the Earth's gravitational field is different to that of matter, this could provide clues about why our Universe is now dominated by matter, even though matter and antimatter were created in equal amounts during the Big Bang.

Until now, Stephen has worked with matter – neutral atoms and molecules initially in their ground states and travelling in beams. "We use lasers at precisely defined wavelengths to stimulate the atoms to highly excited 'Rydberg' states where the electron charge is 'spread' out around the atom," explains Stephen, "Enrico Fermi called atoms in these states 'fat atoms'."

All atoms and molecules possess Rydberg states with similar general properties; their sensitivity to electric fields means that they can be manipulated using appropriately designed electric field distributions. Stephen can decelerate and trap these atoms and molecules for applications in cold chemistry and quantum information processing.



Inside AEgIS © CERN

Working with antimatter is a little different, says Stephen, "In the AEgIS experiment, the antihydrogen atoms are produced by combining antiprotons and positrons. As a result of the formation process, the antihydrogen is produced in Rydberg states – the antiyhdrogen atoms are 'fat antiatoms' – but it is important that we make sure that we control the formation correctly to achieve the highest efficiency. Unlike my experiments on matter, the antihydrogen atoms are formed at rest or with very low velocities so we will use our techniques to accelerate them; to transport them and make beams with very well defined characteristics."

Science & Technology Facilities Council

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This quantum magic will now be exploited in the AEgIS experiment to accelerate antihydrogen atoms in excited states to precisely defined velocities so that the collaboration can make precise studies of the internal structure of antiatoms and measure the acceleration of antimatter in the Earth's gravitational field.

"No-one has ever measured this before," adds Stephen, "We know that in our observable Universe there is an asymmetry between matter and antimatter, but there is no consensus among the theorists as to why this is. If gravity is different for antimatter, this might give us a clue. The results of our experiment will help guide us toward an appropriate theory."

Focusing lasers on a new generation of ideas

The next generation of particle accelerators will require new technology. Whether this is for compact machines that could be used within hospitals to treat cancer patients, or for enabling experiments beyond the Large Hadron Collider (LHC), a new approach is needed.

Radio Frequency (RF) technology is commonly used in particle accelerators such as the LHC, ISIS neutron source or Diamond Light Source, but its applications are limited by the size and cost of the machines that need to be built to deliver the required beam intensity; fundamental scientists are requiring ever more intense beams of particles to explore exotic physics, and applied scientists are looking for ways to make particle accelerators compact, or even portable. Both need a solution that is affordable, but still delivers.

One alternative to RF is to accelerate particles with a laser and LA^{3}NET, a new Marie Curie Initial Training Network (ITN), is bringing early stage researchers, experienced academics, leading research institutes and industry together to look at how lasers can be used in particle accelerators.

The network is funded to enable 17 fellows to each spend three years at their host institution working on applying laser technology to areas such as particle sources, charged particle beam acceleration, developing beyond state-of-the-art instrumentation, optimising beam performance, timing systems and detector technology. Some projects will undoubtedly lead to prototypes, and many will deliver proof of principle.

Alongside the obvious scientific outcomes, many of the projects will be realised in the frame of a PhD project. Each trainee is based with one of 11 beneficiary partners around Europe such as CERN, STFC or the Universities of Dundee and Liverpool, but the network also includes 19 other associate and adjunct partners who provide specialist training, networking opportunities and secondments. Eleven of these partners are from industry. "The network aims to turn out researchers who are fully trained and ready to become principal investigators or research leaders in industry," explains Rob Ashworth, Project Manager (Cockcroft Institute and University of Liverpool). "Technical skills are vital, but we also make sure that they have excellent networking, communication and project management skills. We're putting these trainees on the fast-track."

One of the most interesting aspects of the project is that it promotes international thinking - the trainees are not allowed to have lived in the country in which they will be based for more than 12 months in the last three years. So Tom Day Goodacre from the UK is based at CERN, and Alexandra Alexandrova from Russia is based at the Cockcroft Institute. "Many research collaborations are international and researchers will be expected to be move around the world as their career develops. LA^{3}NET establishes this way of working as the 'norm'" says Rob.

For the early stages of LA^{3}NET, the trainees learn from the experts in the field. A series of international LA^{3}NET events kicked-off in October 2012 with an international school on Laser Applications held at GANIL, France. But as the project develops, the tables are turned and it is the trainees who are sharing their innovative ideas and making an increasingly important contribution to the knowledge base,

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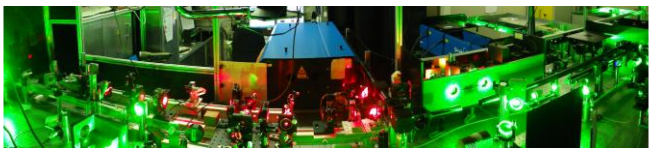
alongside the experienced academics in the network.

"I joined LA^{3}NET in October after finishing my Masters in photon science at the University of Manchester," says Tom. "My project is based at ISOLDE, CERN's radioactive beam facility – I'm an operator on the Resonance Ionisation Laser Ion Source (RILIS), and I'm aiming to improve the efficiency of the ionisation schemes. The first LA^{3}NET school in GANIL was particularly useful for making contacts both within and outside of the network. I'm hoping to visit the University of Mainz in Germany later this year to learn more about their research into laser development."



The RILIS laser table © CERN

The ITN project concept is suiting Tom, "I'm really enjoying the hands-on, practical side of the project – being able to combine a job and a PhD is the perfect combination for me."

Tom will be presenting some of the future plans for the rest of his project at a workshop on laser ion sources organised by LA^{3}NET and taking place at CERN in February with 50 participants.

Alexandra's background is in laser physics. "Accelerators can be applied to a variety of medical, industrial, and energy problems and the laser is a powerful instrument for various parts of a particle accelerator; it can be used as a plasma generator, electron driver or in ion acceleration. But is it also a useful tool for spectroscopy, velocimetry and interferometry. I am working on the development of a laser velocimeter for monitoring a gas jet based beam monitor. It will simultaneously measure its density and velocity. The device is based on principals which haven't been used for velocimetry before so I am developing something new and potentially useful in lots of fields."

"During the networking events and schools, it's very easy to meet new people who can help you with your project. In the scientific world, people are really happy to help you as much as they can. There are lots of projects within LA3NET and it was nice to meet all the other participants because we can help each other. We are one team together."

LA^{3}NET is coordinated from the Cockcroft Institute/University of Liverpool by Carsten P. Welsch.

Designing the right environment

The right working environment can contribute to improved creativity, productivity and communication. CCD Design & Ergonomics Ltd is a UK-based specialist consultancy that has been working with CERN to produce a design which will transform the layout of the main Design Office.

The Design Office plays a crucial role in the design of components for CERN's accelerators but the designers work in an environment that no longer reflects the significance of the tasks they undertake. The current use of the space in the design office is inefficient and could offer more workspaces.

CCD uses a combination of architects, interior designers and industrial designers alongside ergonomists and psychologists to produce its proposals. This approach worked very effectively when CCD designed the layout for the CERN Control Centre in 2007.

The design office team wanted groups of large desks that would provide a good balance between privacy and opportunities to communicate and work with colleagues sat close by. They wanted a variety of distinct spaces that would allow them to separate noisy activities from quieter ones, and to offer increased flexibility to how they work. Another major aim was to improve the environmental design, and in particular make better use of natural daylight, and control noise.

"We use an international standard in our design work and part of the process involves gathering the views of the users," explains Paul Reynolds, Senior Consultant at CCD. "In this case, every

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member of the team received a questionnaire. Their responses helped us create a design brief and from that, a series of layouts. We then worked with the team to whittle down the options and produce a detailed design. For a project like this to work, it is essential that the people who actually use the space are involved in its improvement."

The developed design provides an open plan area with six groups of large desks and two clusters of smaller desks separated by acoustic screens, shared meeting tables, whiteboards, storage and architectural elements. Use of natural daylight is improved by carefully balancing the height of the acoustic screens and other elements between the desks to provide some privacy whilst allowing daylight to pass over them. The acoustic screens and some acoustically absorbing materials mounted on the walls control noise levels.

CCD's proposal for the CERN Design Office © CCD/CERN

Adjoining the main open plan space there is a small meeting room and two break-out areas.

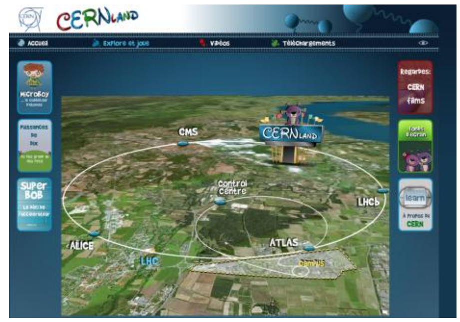
Computing and printing equipment is situated in distinctly separate spaces and a new reception space and meeting/conference room will improve the handling of visitors. The new layout of spaces keeps noisy activities such as printing and teleconference meetings separate from the open plan space, and glazed partitions allow daylight to be shared between the spaces.

The design office team is very pleased with the results and keen to implement the changes in the near future.

And finally….

Have you visited CERNland recently?

This is CERN's special website for children. With lots of interactive games, multimedia applications and videos, it's a fun way to learn about CERN and particle physics, even if you're not aged 7-12 yrs!



CERNland © CERN

CERNland aims to inspire and excite children about physics before they begin to make decisions that will influence their future career paths. The site has been developed with the help of professional educators and assisted by some of the young people in the age group that it has been designed to reach. Their input has been incorporated into the site's design.

Anyone can follow Super Bob round the LHC or try building atoms by collecting electrons, protons and neutrons - why not see how you get on?

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Diary dates

CERN Council week –18-22 March
LHC on Tour in Belfast – 6-10 May
CERN public open day – 29 September

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