DESY PRESS RELEASE, Hamburg, 5.12.2002

Fireworks in noble gas clusters

A first experiment with the new "free-electron laser"

An international group of scientists has published first experiments carried out using the new soft X-ray free-electron laser (FEL) at the research center DESY (Nature, vol 420, p 482-485 and p 467). Using small clusters of noble gas atoms, for the first time, researchers studied the interaction of matter with intense X-ray radiation from an FEL on extremely short time scales. "We use noble gas clusters as relatively simple model systems to understand fundamental processes which will be important for future investigations of technologically interesting materials or medically important biomolecules " explains Prof. Jochen R. Schneider, research director and head of the Hamburg Synchrotron Radiation Laboratory HASYLAB at DESY.

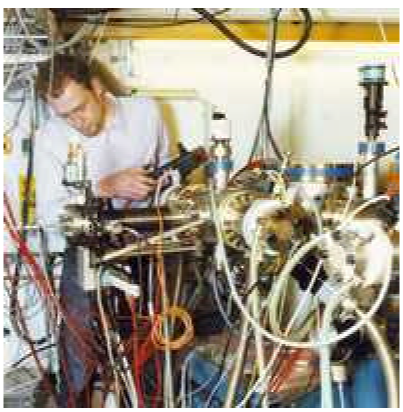
The free-electron laser at DESY generates very intense laser light at wavelengths below a 100 millionths of a millimeter, a range called soft X-ray radiation. These are the shortest wavelengths ever generated by an FEL. The peak brilliance of this new laser is a thousand times higher than those of the best current light sources in this wavelength range. Moreover, an X-ray flash of the FEL lasts for only a 100 quadrillionths of a second - this is the time scale where chemical bonds form and atoms change their position. Therefore, chemical reactions can be observed directly.

In a first experiment, clusters of the noble gas Xenon were irradiated with the intense laser light. "What happens can be compared to a microscopic fireworks display" describes DESY physicist Dr. Thomas Möller, who leads the cluster experiment. The Bjørn H. Wiik Prize 2002 was recently awarded to Dr. Möller for his scientific work. "When excited by the intense X-ray flashes, the nobel gas atoms emit more and more electrons thus forming a plasma. Partly, even multiply positively charged atoms develop. As a consequence the cluster "explodes", because of the repulsion of the ions". The details of this explosion reveal fundamental principles of the interaction of intense X-ray radiation with matter. These questions can be approached for the first time. Due to the intensity of the radiation from the free-electron laser, a single light flash can manifest considerably more information about the structure of matter than ever before.

A group of scientists from DESY, from the Brazilian science center Laboratório Nacional de Luz Síncrotron and from the Russian Joint Institute for Nuclear Research carried out these first experiments with the free-electron laser. The FEL is part of a 100-meter long test facility for the future project TESLA at DESY. This facility is currently upgraded for two purposes: first, to test the TESLA linear collider technology for particle physics; second, to run a more powerful free-electron laser for even shorter wavelength radiation down to 6 nanometers (millionths of a millimeter). From 2004, this unique light source will be available to scientists from all over the world for their experiments. At the same time it will be used as a pilot facility for the TESLA X-ray laser, designed to produce even shorter wavelength X-ray radiation in the range of 0,1 to 1 nanometer.

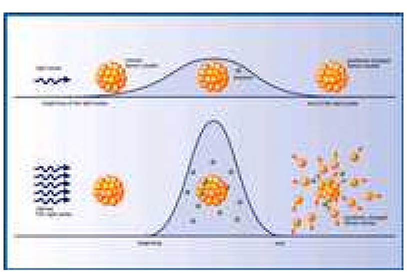
TESLA stands for TeV-Energy Superconducting Linear Accelerator - a particle accelerator facility operating at tera-electronvolt energies. The facility will comprise of a 33-kilometer-long linear accelerator used to collide electrons with their antiparticles, the positrons, as well as an X-ray laser laboratory. Novel types of superconducting accelerators will allow particle collisions with highest energies and serve as a source of intense and extremely short X-ray flashes with laser-like properties. Future areas of research will range from studies of the structure of matter and its creation during big bang to novel technological materials or the processes of life. A final decision regarding the TESLA project can be expected in 2003. TESLA is to be established and operated as an international center. After project approval, a construction period of eight years is envisioned and TESLA could be ready to take up operations at the beginning of the next decade.

.



Cluster experiment at the free-electron laser
Physicist Hubertus Wabnitz, one of the authors of the *Nature* paper, at the cluster experiment. (Source: DESY Hamburg)

150 dpi oder 300 dpi



Cluster experiment at the free-electron laser
When matter is irradiated with very intense light, unusual processes occur, which do not happen after irradiation with less intense light. Detailed figure caption see below. (Source: DESY Hamburg)

150 dpi oder 300 dpi

Detailed figure caption "Cluster experiment at the free-electron laser"

When matter is irradiated with very intense light, unusual processes occur, which do not happen after irradiation with less intense light. In the last two decades, the interaction of intense infrared and visible light with matter has been investigated in detail. In contrast, effects of intense short wavelength UV and X-ray radiation could not be observed because appropriate light sources were not available. The new free-electron laser at DESY opens up this field of research and first experiments show that intense X-ray light has far more dramatic effects on matter than much weaker "conventional" X-ray light.

Top:

A cluster of a few hundred Xenon atoms is irradiated with light flashes from a "conventional" light source and absorbs one high-energy photon. Excited by this energy, an electron is ejected from the cluster leaving a positively charged Xenon cluster behind.

Bottom:

A Xenon cluster is irradiated with the intense light flashes of the free-electron laser and absorbs many high-energy photons. At first, some electrons leave the cluster. Yet the process continues: due to irradiation with such highly intense light, the cluster continuously absorbs new photons. Thus, the electrons reach highly excited energy states. However, only rarely do they have enough kinetic energy to leave the cluster completely. According to model representations of physicists, a so-called nanoplasma forms after a few femtoseconds (Am: millionths of a billionth of a second oder quadrillionths of a second oder GB: thousandths of a billionth of a second): The positively charged Xenon cluster is surrounded by a negatively charged "cloud" of high-energy electrons, which may linger a certain distance away from the cluster but are still confined by the positive charge.

When - in this manner - more and more electrons leave the cluster and are confined in the cloud, also more and more positively charged Xenon ions emerge. These ions can even be multiply charged. They all repulse each other so strongly that the cluster "explodes" and the Xenon ions speed into all directions.

More pictures and background information about TESLA