Cryebis and ECR

The fast ion beams produced by the Tandem and LINAC can be stripped to high charge states by passing them through thin foils, thus reaching a state of ionization/solventization comparable to an atom in a gas heated to roughly 10 million degrees. An alternative way to produce such highly stripped ions is to hold the ion still and subject it to an intense beam of electrons.

The Cryogenic Electron Beam Ion Source (Figure 4) and the Electron Cyclotron Resonance ion source follow this route, producing slow beams of highly charged ions. The Cryebis does this by immersing atoms in an extremely intense (10^10 A/cm^2) electron beam. The ECR source does it by developing a plasma with a producing high-energy electron flux.

The Cryebis can be used to fully stripped argon and helium ions instead xenon. The ECR source produces more intense beams of several megawatts. The LINAC produces its beams as stand-alone low-energy accelerators for delivering beams to target stations. The LINAC can be controlled to fully stripped argon and helium ions instead xenon. The ECR source produces more intense beams of several megawatts. The LINAC produces its beams as stand-alone low-energy accelerators for delivering beams to target stations.

Lumos

Researchers in the LUMOS laboratory (Figure 5) are working to create stable optical frequency combs by sending ultrashort laser pulses through specialty optical fibers. This generates a rainbow of optical frequencies, or a supercontinuum. The properties of the rainbow spectrum that emerges from the fiber can be measured and used to stabilize the ultrashort laser beam. The stable pulse train, when amplified, can be used for atomic physics experiments.

In addition, the broad spectrum is actually a comb of optical frequencies that spans the visible or near-infrared end of the spectrum. When stabilized, this comb forms a frequency “ruler” that can be used to measure unknown optical frequencies to very high precision.

The LUMOS optical frequency comb will be used to make precise measurements of optical frequencies in molecular gases important for frequency standards in the telecommunications industry. By combining these gases in novel photonic bandgap fibers, precise evaluation spectroscopy can be performed to improve the convergence and accuracy of these standards. The frequency comb can then be used to study fundamental physics issues, such as atomic physics, optical physics, and quantum information science.

Motrims

If the electrical power from a wall outlet is used in just the right way, it can be used to cool things down (as in a refrigerator) rather than heat them up. Similarly, if the power from lasers is used in just the right way, it can be used to cool atoms down, rather than heat them up.

In the MOT room (Figure 6), researchers use lasers to cool atoms down to a temperature far lower than anything found in nature, more than a million times colder than room temperature. When a group of atoms are cooled, their average speed is reduced. Furthermore, their spread in speed is reduced. That is, if all of the cooled atoms move at nearly the same speed, and that speed is very low (vibes per second, rather than a thousand feet per second at room temperature).

These very slow atoms are then used as targets, with ions used as the “bullets.” Because the target atoms are moving so uniformly and slowly before their collisions with the ions, their motion after a collision yields much more information about their interaction with the ion during the collision.

Other lasers can be used to excite these slow atoms before their collision, allowing researchers to control the ion beam interaction with these excited atoms. These measurements can be used to determine the efficiency of the ion beam interaction with the atoms.

Theoretical AMO Physics

The theoretical AMO group strives to provide fundamental understanding of experiments carried out in the Macdonald Laboratory and elsewhere. This includes principles of classical and quantum mechanics. A broad range of problems are being investigated.

For interactions of short-pulse lasers with matter, we are looking into the near-future physics of attosecond (10^-18 sec) laser pulses. We are also investigating the interaction of molecules in an intense laser field. By understanding how a molecular break, a “molecular clock” can be made where time can be read with a precision of less than a femtosecond such that distances can be determined with an accuracy of a fraction of an Angstrom (.10^-10 cm).

Theoretical AMO physicists are also being developed to study the interactions of laser-light and particles with clusters (C60), thin films, atomically flat, and nano-structured surfaces. Our calculations of basic electron transfer and recombination processes in the interaction of a slow projectile atom or ion with a surface are both fundamental interest and of practical importance for various areas of science and engineering, such as the development of ion sources, the improvement of surface analytical methods, the control of ion-wall interactions in fusion plasma, reactive ion etching, nano-technology, and the investigation of interplay of ions with atoms and molecules.

With regard to “broad” physics issues, we are working on collisions of anti-protons and positrons with simple atoms, on the structure and stability of very-light atomic and molecular ions, and on guiding the Bose-Einstein condensate in a dipole.
The laboratory employs about 50 people to handle the activities in this large scale research facility. The equipment found there provides high-intensity, short pulse laser beams and energetic beams of heavy ions for use in fundamental experiments in atomic physics.

The basic atomic physics experiments conducted in the Macdonald Laboratory provide a deeper understanding of the dynamics of matter when atoms are subjected to ultra-tight electromagnetic fields and/or stripped of many electrons. The results of these experiments and the associated work by our theory group find applications in astrophysics, fusion technology, quantum computing, ultraviolet "cameras", telecommunications frequency standards, and surface science. A central mission of the laboratory is to train young physicists in preparation for careers in physics.

The initial cost of the Tandem Van de Graaff accelerator facility in 1967 was $2.5 million. Of this, $1.5 million was from the U.S. Atomic Energy Commission, the U.S. Department of Energy, and $1 million from the state of Kansas. In 1986 a laboratory extension was added, the Kansas Light Source, which added another $1 million from the state of Kansas and $1 million from the state of Kansas. In 1986 a laboratory extension was added, the Kansas Light Source, which added another $1 million from the state of Kansas and $1 million from the state of Kansas.

The basic atomic physics experiments conducted in the Macdonald Laboratory provide a deeper understanding of the dynamics of matter when atoms are subjected to ultra-tight electromagnetic fields and/or stripped of many electrons. The results of these experiments and the associated work by our theory group find applications in astrophysics, fusion technology, quantum computing, ultraviolet "cameras", telecommunications frequency standards, and surface science. A central mission of the laboratory is to train young physicists in preparation for careers in physics.