The Canadian Penning Trap Mass Spectrometer

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The Canadian Penning Trap (CPT) Mass Spectrometer was originally constructed at the TASCC facility in Chalk River [1]. When that facility was closed in March 1997, the CPT was moved to Argonne National Laboratory, where it was reassembled, and re-commissioning begun in late 1998. The CPT Mass Spectrometer is now operated by a collaboration involving scientists from Argonne National Laboratory, the University of Manitoba, McGill University and Texas A&M.

In its new configuration, the CPT will be available to measure the masses of products of heavy-ion reactions induced by beams from the ATLAS facility on a thin target located in the target chamber of an Enge split-pole spectrometer. Products recoil out of a target, and the nuclides of interest are separated from the primary beam and other unwanted contaminants by the Enge, which is used as a gas-filled magnetic separator. This technique has the advantage that the reaction products can be efficiently collected over a wide range of energies and charge states. At the exit of the separator, the recoils pass through a thin window and are stopped in a gas cell containing helium at a pressure of 100 Torr. The ions are carried out of the cell by gas flow and enter a linear radio-frequency quadrupole device (a gas cooler) that resembles a modified quadrupole mass-filter. Here the ions are confined by the RF fields while the helium is pumped away. They accumulate (and are cooled by collisions with the residual gas) in an ion trap incorporated into the end of this device. From here, they are periodically ejected in pulses and transported to a Paul trap, which is the first stage of the CPT itself.

Helium buffer gas (at 10^{-5} Torr) present in the Paul trap makes it possible to accumulate and cool a train of ion pulses. When sufficient numbers of ions have been accumulated, the ions are ejected and transported to the precision Penning trap located in the bore of a superconducting, 6-T magnet of high stability and homogeneity. Once captured in the trap, the motion of the ions can be characterized by three fundamental frequencies: the reduced cyclotron frequency, ω_+, the magnetron frequency, ω_-, and the cyclotron frequency, ω_c. Of these, only ω_c can be used for precise and accurate measurements of the mass of the ions. This frequency is determined for the trapped ions by means of the time-of-flight technique [2] developed by the ISOLTRAP group at CERN. The CPT mass spectrometer has been designed to achieve an ultimate precision of $\delta M/M = 10^{-9}$.

Currently, commissioning tests are proceeding simultaneously with stable platinum and gold ions, and with radioactive species produced from ATLAS. The CPT itself is performing well but difficulties are still being encountered in transporting recoil products to the CPT in large numbers.

References

[1] G. Savard *et al,* Nucl. Phys. **A626** (1997) 353c.

[2] G. Bollen *et al*, J. App. Phys. **68** (1990) 4355.