A new generation of room-temperature electron-beam ion traps with straight-through, on-axis optical access

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Synopsis A series of permanent-magnet electron-beam ion traps is being developed for applications such as a source of ions for precision spectroscopy in low-temperature traps, and studies at synchrotron radiation and X-ray free-electron laser beamlines.

EBITs (Electron-Beam Ion Traps) are a standard tool for the production and study of highly-charged ions (HCI). State-of-the-art devices use superconducting magnets to strongly compress a high-current electron beam and can create and trap almost any charge state of almost any element. However these are large instruments and there is a demand for smaller, more economical devices which can be used when ions in intermediate charge states are of interest - for example for extraction and trapping in precision Penning or Paul traps for measurements at low temperatures. A further development is to allow straight-through, on-axis access to the trapped ions, to improve access for, for example, a beam of synchrotron radiation or from a laboratory or free-electron laser lightsource.

To this end we have developed a new generation of room-temperature EBITs which use NdFeB magnets, combined with soft iron or permendur pole pieces to generate magnetic fields of up to 1 T at the trap centre. Using an on-axis electron gun beam currents of the order of 50 mA over the energy range of 1 keV to 8 keV have been demonstrated, with 25 mA achieved for the off-axis gun.

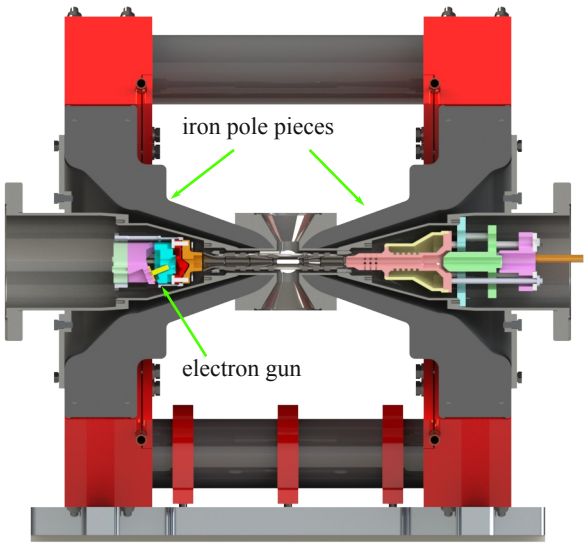

Figure 1. Cross-section schematic of a permanent-magnet EBIT with an off-axis electron gun.

Figure 1 shows a cross-section schematic of one of the new EBITs in a plane through the trap centre and containing the electron-beam axis, with the off-axis electron gun on the left (cathode shown in yellow) and the collector/extraction optics on the right.

Figure 2 shows example X-ray emission data recorded using the off-axis electron gun EBIT, with electron impact on neutral argon gas providing a source of HCI, and emitted X-rays detected using a solid-state detector. The spectra reveal emission from recombination processes in highly-charged argon ions, demonstrating the efficient operation of the device.

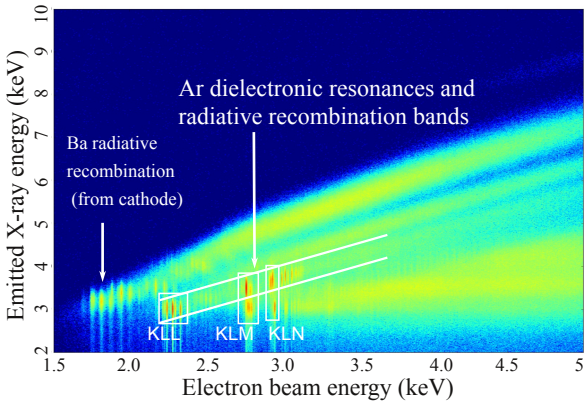

Figure 2. X-ray spectra recorded from highly-charged argon ions in the off-axis trap.

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