Antiproton Compression and Radial Measurements

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The current generation of antihydrogen ($\overline{\mathrm{H}}$) experiments aims to trap $\overline{\mathrm{H}}$ atoms as this is likely necessary for precision CPT and gravity tests. Neutral $\overline{\mathrm{H}}$ atoms have a small permanent magnetic moment, and can be trapped in a magnetic minimum. Traps based on this effect are called Minimum-B traps. To trap both charged and neutral species simultaneously, the Minimum-B and Penning-Malmberg traps must be co-located. The compatibility of Minimum-B and Penning-Malmberg traps remains controversial, but it is clear that the two are most compatible if the antiprotons ($\overline{\mathrm{p}}$'s) and positrons (e^+'s) are held close to the trap axis where the perturbations from the Minimum-B fields are smallest.

Here we report measurements of the radial extent of the $\overline{\mathrm{p}}$ clouds, and a method to compress these clouds to very small radii. We use two methods to measure the radial extent. The first is based on a micro-channel plate (MCP) and phosphor screen, and provides an image of the $\overline{\mathrm{p}}$'s similar to that shown in Fig. 1. Apertures limit the size of the plasma that we can measure to about 1.5 mm. The second uses the time history of the loss of particles when our octupole magnet is turned on to reconstruct the outer radial profile. (The octupole is used to generate the radial minimum-B fields required for our $\overline{\mathrm{H}}$ trap.) This diagnostic can measure the $\overline{\mathrm{p}}$ profile between about 7 mm and the trap wall. Using these diagnostics to determine the $\overline{\mathrm{p}}$ radius, we have successfully compressed our $\overline{\mathrm{p}}$ plasmas down to radii as small as about 0.3 mm, and increased their density by a factor of ten. We compress the $\overline{\mathrm{p}}$'s by applying a rotating electrostatic field to the electron (e^-) plasma used to cool the $\overline{\mathrm{p}}$'s. This sort of field is well known to compress particles trapped in Penning-Malmberg traps. In our case, the compressing e^- appears to drag the $\overline{\mathrm{p}}$'s with them, resulting in a compressed $\overline{\mathrm{p}}$ cloud.

This work was supported by CNPq, FINEP (Brazil), ISF (Israel), MEXT (Japan), FNU (Denmark), NSERC, NRC/TRIUMF (Canada), DOE, NSF (USA), EPSRC and the Leverhulme Trust (UK) and HELEN/ALFA-EC.

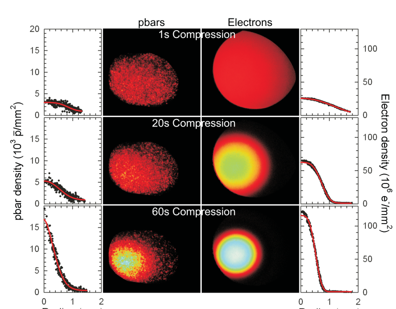

Figure 1: $\overline{\mathrm{p}}$ and e^- images showing the effects of compression, and the resulting radial profiles.