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Trapped and cooled 88Sr+ ions in a cylindrical potential provided by a micro-fabricated ring trap

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Laser-cooled trapped ions platform is one of the best candidates for the development of future quantum computing. This has generated a major worldwide research effort aimed at scaling and integrating trapping devices. As part of this effort, we are developing miniature atomic ion traps in the laboratory: Paul linear surface traps manufactured in collaboration with Nanyang Technology University and the Microelectronics Institute of Singapore. An original feature of the manufacturing process is that all the electrical contacts of the trap electrodes are made through the Silicon substrate (TSV: through silicon vias). In this way, the wire-bondings usually soldered directly to the electrodes can be offset or completely eliminated [1]. This opens the way to complex architectures, in particular cylindrically symmetrical ring traps, which cannot be made with surface connections that would break the desired symmetry.

The trapping and laser cooling of ions in cylindrically symmetrical linear Paul traps (called "ion storage rings" in their macroscopic version, diameters of around 100 mm) was demonstrated in pioneering work at Garching [2] and subsequently extended to microfabricated traps (multilayer technology) at Sandia National Labs (diameter 2.5 mm) [3] and Berkeley (diameter 95 µm) [4]. These devices are of interest because, in the absence of defects, they enable rotational symmetry for the trapped ions and thus periodic boundary conditions for the confined cold ion system (Coulomb crystal). They are also candidates for observing and manipulating the rotational quantum state of trapped ion ensembles [4].

We will present our latest results concerning the performance of TSV surface ring traps (diameters between 150 and 210 µm) manufactured in Singapore. In particular, we loaded these traps with Doppler-cooled 88Sr+ ions (from a single ion to several hundreds). Laser cooling and image acquisition enable us to estimate the defects of the trapping potential with respect to perfect rotational symmetry. The application of DC voltages to a set of segmented electrodes then makes it possible to compensate for most of these defects, which nevertheless remain the major problem to be solved in order to achieve sub milikelvin free motion.

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