TEQ meeting: Definition of parameters for particle ion trap and optical detection
London – 28 March 2018

Minutes

Venue:
University College London,
Department of Physics and Astronomy,
Gower Street, London.

Participants:
Peter Barker (UCL) - host
Michael Drewsen (AU)
Andrea Vinante (UoS)
Antonio Pontin (UCL)
Hendrik Ulbricht (UoS)
Anis Rahman (UCL)

1) Summary of the meeting

Experimentalists of the TEQ Consortium met to discuss the design and realization of the experiment of the Project. This meeting aims at discussing, and consequently update the TEQ partners, on experimental parameters required for the preparation of the TEQ experiment. The meeting focused on the details of the Paul ion trap design, voltages needed to supply the Paul trap, noise levels to be reached to perform the desired test of CSL noise as defined by TEQ. It followed a discussion on the sourcing and loading of the particle into the Paul trap at vacuum and low temperature. First details about the detection of the particle in the trap were discussed. The next steps of progress with preliminary experiments and manufacture of components (as are Paul trap blades, electronics, particle source, cryostat, etc.) were defined in preparation of the next TEQ meeting to be held in Southampton in June 2018.

2) **Notes from the meeting (internal use only)**:

- **General discussion**:

Magnetic trapping of dia-magnets (large magnetic fields needed, Philadelphia group) is an alternative option, but for now ion trap is favoured.

Force noise for $\lambda = 10^{10} s^{-1}$, need force sensitivity of 10^{-22}N/sqrt{Hz}.
Estimate low vibration noise, LIGO, … z-spring, vertical attenuation is usually better than horizontal attenuation (needs to be considered for desing of cryostat and vibration isolation in cryostats).
Oriol's paper on trapping of ferro-magnets (single domain) in low magnetic fields.
Rotational degree is interesting as sensor, not clear how to rotate in a Paul trap.

- **Things to sort for Paul trap**:

Noise level needed from electronics and power supplies for Paul trap.
Set target for Max to build the new electronics: xxx V/sqrt{Hz}.
Heating mainly from the DC voltage on Paul trap.
Filter the DC voltage power supply to reduce noise from there applied to the trap.
Keep conditions of Paul trap constant or ramp voltages? This has effect on choice of amplifiers: measurement at constant conditions, trap and prepare particle and then measure position noise stroboscopically to detect heating rates and compare to collapse model's predicted noise.
Electro spray source: up to 5000 charges on a 600 nm particle, 1 kHz trap frequency.
Buffer gas cooling with 1mbar of neon which is in the system during cool down.
Loading problem: electrospray source or piezo (the latter would need to use a method to charge particles: optical or alpha emitter), clean particles or build an ion guide into the trap.

Use metal nanoparticles with lower work function.
Use a mercury or Excimer lamp to ionize more or add charges.

Hendrik: play with piezo sources to load optical trap and check charges (Andrew Geraci has a working source).

Number of electrodes/wires: how many of which types of wires for the cryostat.
Go for Monroe design:
Laser cutting for ceramics for blades: Michael to find a company.
Shapal for ceramic blades (has better thermal conduction, compared Macor).
Gold coating (Michael can find out).
Drawing for the trap.

- **Things to sort for the detection**:

Cavity or not.
Optical detection needs to be symmetric to not push particle out of the trap.
What finesse of cavity to detect the position well enough.
Low finesse cavity for detection, feedback cooling, DC of Paul trap must be tuned to avoid noise of optical feedback.
Calculate the temperature of the com motion needed to have a well localized trap position to cool with the cavity.
Orientation of cavity with respect to Paul trap – along z-axis or perpendicular?
Estimate heating rate from detection compared to collapse heating rate.
Multi-mode optical fibre close to the particle to image …
Optical fibre or free space: is free space going through the Liquid helium region? Maybe fibre coupling is better.