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Project final report

Scientific objectives

Familiarisation of trapping and cooling techniques for ions

The starting point of the project was to assemble a micro ion trap with integrated optical fibres according to the design made by the host group. During the assembly and installation of the trap we discovered several unexpected points, which were not taken into account in the original design [1]. This resulted in extra work to develop a new improved design of the micro ion trap and the corresponding experimental apparatus for its further operation [2-3].

In order to gain experience in trapping and laser cooling of single ions during this demanding development work, I decided to carry on in parallel ion trapping experiments in an another ion trap. This trap is one of the two already operating ion traps in the host group. We first performed trap optimization for single and few ions operation. Second, Doppler laser cooling was performed and optimized. Finally, we carried out sideband laser cooling of single and few ions to prepare them in the ground state of the trap [4-5], for this is a prerequisite to further quantum information processing operations.

Obtaining expertise in working with few ions in micro-traps and implementation of single ion addressing via lensed optical fibres

The additional trap development work caused a delay in the assembly and the test of the final fibered micro ion trap. Although this extra work did not allow me to perform ion addressing using optical fibers, it allowed me to get valuable deep insights into the ion trapping technology [1,3,6].

Production of laser beams with tailored intensity distribution

We studied various methods for tailoring radial intensity distribution in laser beams: computer generated holograms, step phase plates and Fabry-Perot resonators. We performed numerical simulations to select the most promising candidates for creating intensity distributions necessary for addressing. These methods were then experimentally tested and characterized [7].

Addressing single ions via EIT process

Taking into account the amount of the development work and the availability of human resources dedicated to the project, it was decided to concentrate the main project efforts on the laser cooling experiments and development of the firm theoretical model of the addressing process based on the effect of Electro-magnetically Induced Transparency (EIT).

Developing a firm theoretical understanding of EIT processes and exploring the possibility of using EIT in gate operations

In collaboration with the theoretical group, which proposed to use EIT for single atom addressing, I adapted the scheme for calcium ions that we use in our project. Moreover, I extended the proposed single qubit phase gate to arbitrary qubit rotations. The main outcome of the theoretical work was to estimate the effect of different experimental imperfections on the fidelity of the addressing in order to simplify and optimize the experimental setup [8-9].

Career objectives

Management of a high-level research project and gain experience to start my independent research career

My gain from the fellowship is threefold. First, during this project I managed the research work and made strategic decisions to direct the flow of the project. This allowed us, despite discovered challenges, to perform high quality research work [3-4,8-9]. Second, I was able to travel to international conferences [9-11] and to establish fruitful scientific collaborations with theoreticians. Finally, I supervised several Bachelor, Masters and Ph. D. students working on this project [1,2,5-7]. This supervision work, together with my tutoring and lecturing at the department of Physics and Astronomy during the last two years, gave me valuable teaching experience.

This combination of the management experience, together with the deep theoretical and experimental understanding of the field, helped me to develop a scientific research programme for my future work as an independent researcher. Combined with the teaching experience, I am well equipped now for getting an assistant professor or a lecturer position. Recently, I was already invited for a job interview for a lecturer position at the University College London (UK).

References

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