Report:FA045 Collaborative Visit NUI Maynooth/Bratislava April 2003

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In April 2003, I visisted the group of Prof. Vladimir Buzek in the Research Centre for Quantum Information in Bratislava, Slovakia and attended the Young European Physicists conference in Budmerice over a period of 6 days.

This visit allowed for me to meet the group and discuss different aspects of quantum state reconstruction based on complete and incomplete measurement data. Of particular interest is the Jaynes principle of maximum entropy [2] and its application to quantum state tomography. This method of reconstructing a quantum state is quite appealing since the reconstructed state is uniquely determined as that which is maximally non-committal with regards to missing information. It is quite a powerful scheme given incomplete information as has been demonstrated in [1]. The main drawback is that although in principle any state can be reconstructed with this scheme, in practice it involves a minimization process over N Lagrange multipliers, where N is the number of observables measured in a given experiment. Thus it is not always the case that a unique solution exists, or at least it is not always possible to know that the solution found is unique.

While in Slovakia, I also attended the YEP conference on the subject of 'Experimental Realisations of Quantum Bits'. The conference lasted 4 days with talks from participants in the mornings and afternoons. I presented a talk entitled 'Quantum Computing with Ion Trap Spin Molecules'. Overall I found the conference to be extremely informative. Most participants were at the same stage in their research, so it was an excellent setting to meet and discuss physics.

Since the visit to Bratislava we have performed numerical simulations of quantum state tomography using the maximum entropy reconstruction scheme. Firstly, we investigated how well the scheme works using data generated from a Wigner distribution function at twelve points in phase space. Using measures from [1] we can determine how well the reconstructed state agrees with the actual state.

Following this, we used real data from the Bertet et al. [4] experiment where they directly measured the Wigner function of a one-photon Fock state in a cavity using the Lutterbach and Davidovich procedure [3]. In this experiment, the Wigner function was measured for 11 points in phase space. The photon number distribution was inferred from this which gives us the average photon number. Thus, we have twelve observables. Due to the lack of complete measurement information, this is a good candidate for state tomography using the maximum entropy principle. We carried out this numerical procedure and have reached good agreement. We show below the reconstructed state and also the mixed Fock-state inferred from the Wigner function measurements. We hope to continue this work into the future.

I would like to thank Quiprocone for funding this visit.

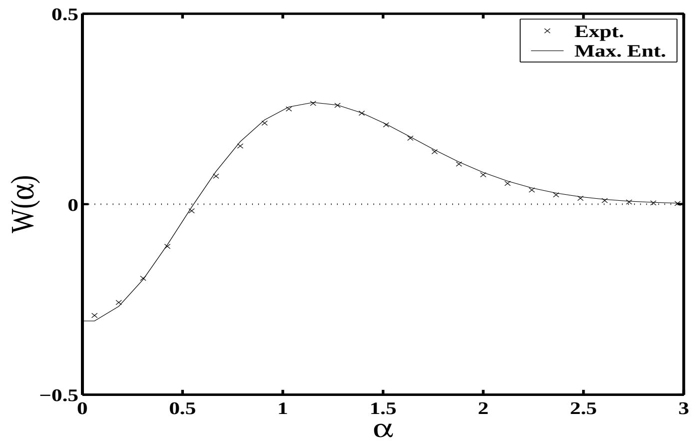

Figure 1: Wigner functions of state inferred from measurement and state reconstructed using Maximum Entropy method for real $\alpha \in [0, 3]$

References

[1] Buzek, V., Drobny, G. Quantum Tomography via the MaxEnt principle. *Journal of Modern Optics* **47**, 2823 (2000).

[2] Jaynes, E.T., Information Theory and Statistical Mechanics. *Physical Review* **108**, 171 (1957)

[3] Lutterbach, L.G., Davidovich, L. Method for Direct Measurement of the Wigner Function in Cavity QED and Ion Traps. *Physics Review Letters* **78**, 2547 (1997).

[4] Bertet, P., Auffeves, A., Maioli, P., Osnaghi, S., Meunier, T., Brune, M., Raimond, J.M., Haroche, S. Direct Measurement of the Wigner Function of a One-Photon Fock State in a Cavity. *Physical Review Letters* **89**, 200402 (2002).