# Bunching of a pulsed atomic source

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An interesting phenomenon involving the quantum statistics of fermions and bosons is the Hanbury Brown-Twiss [1] effect, where interferometric experiments can be performed with the intensity of particles (either in the density of atoms, or $|E(r,t)|^2$ in a classical model for light). The Hanbury Brown-Twiss effect is a second order coherence effect, in contrast with a first order coherence in amplitude such as that measured by a Michelson interferometer. Physically, this amounts to determining the probability of measuring a particle at a position or time, given that other particles exist nearby. Thermal bosons are expected to arrive in bunches, thermal fermions antibunch to avoid one another, and a coherent BEC is uncorrelated (Poissonian).

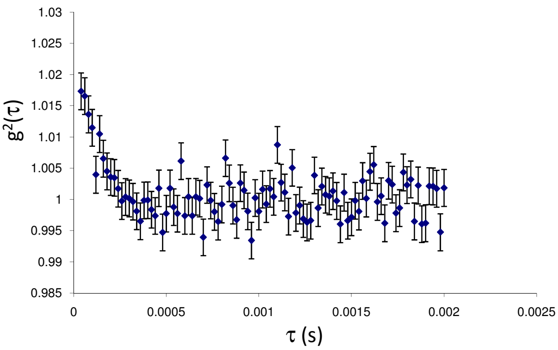


Fig. 1: Second order correlation function for the arrival times of atoms from a thermal source. For earlier times (i.e. times within the coherence time of the source) we observe an increase in the probability that two particles will be detected. This so-called bunching is the result of the famous Hanbury Brown-Twiss effect.

In our experiments, we release thermal atoms from the magnetic trap by applying high power RF pulses which output-couple atoms into untrapped states. The pulses are very short in time and thus have a large frequency spread, resulting in an outcoupled cloud which is an image of the original, only about 30 times lower in atom number. The experiment implements a recently installed delay-line system, which allows the position and time of a detection event to be measured. The delay-line consists of two layers of wire which are wound around a rectangular base, where a signal from each of the two ends of the two wires can be measured. In addition to a signal for the time of arrival, the position of a particle striking the detector can be ascertained from the time taken for the signal to propagate to both ends of the two layers of wires.

We use the pulsing technique since simply dropping the entire cloud on the detector would lead to saturation effects. As a result we can collect large amounts of data from a single run of the experiment and exploit this method to investigate the quantum statistics of a pulsed thermal atomic source.

We observe bunching on short time scales for the pulsed thermal source, as shown in the figure above, while for a pulsed atom laser no bunching is observed (not shown). Performing this experiment is the first of many steps the ANU metastable helium BEC group will be taking to probe further into correlation and entanglement effects in ensembles of atoms. In particular, we aim to investigate the Einstein-Podolsky-Rosen paradox, which challenges the idea of local reality in quantum mechanics, for the first time with massive particles.

## References

[1] T. Jeltes et al., Nature **445**, 402 (2007).