

# Using interference to probe (de) coherence and quantum noise in many body systems

Jörg Schmiedmayer

Atominstitut der Österreichischen Universitäten, TU-Wien

Quantum coherence and Quantum noise, together with the probabilistic character of the measurement process is one of the most puzzling and fascinating aspects of quantum mechanics. Coherence can be observed in interference experiments, but the full characterization of the noise, which in many-body systems quantum can reveal the non-local correlations and entanglement of underlying many-body states remained elusive.

In the talk I will present experiments interfering two 1 dimensional quantum gases [1], which reveal how the coherence slowly dies under the influence of quantum and thermal noise [2]. To reveal the nature of the fluctuations we generalize the standard homodyne measurement of quantum optics to the analysis of interference of two fluctuating quantum systems. The full distribution function of the shot to shot variation of the interference patterns contains information about the higher order correlation functions and reveals the nature of the noise. In our experiments we clearly distinguish between contributions of fundamental quantum noise and thermal noise [3].

In an outlook we will discuss how experiments can be extended and combined with high efficient atom counting to further characterize the quantum states of mesoscopic many body systems. A as complete as possible characterization of quantum physics in these systems will be the prerequisite for efficient quantum control in these fascinating many body systems

This work was supported by the European Union MC network AtomChips, integrated project SCALA, the DIP the FWF and the Wittgenstein Prize.

[1] T. Schumm *et al.* Nature Physics, **1**,57 (2005); S. Hofferberth *et al.* Nature Physics **2**, 489 (2008);

[2] S. Hofferberth *et al.* Nature **449**, 324 (2007);

[3] S. Hofferberth *et al.* Nature Physics **4**, 489 (2008);