PhD Diessertation

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Witnessing entanglement for quantum interferometry

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Abstract

Measurement is the key for our understanding of Nature: thanks to increasingly accurate measures we have been able to investigate more outlying and fundamental phenomena. Interferometry has revealed to be one among the most powerful and precise techniques in metrology. In a interferometer, two (light or matter) waves undergo a phase shift that generates observable interference effects: the aim of interferometry is measuring these effects in order to estimate the phase shift with the smallest possible uncertainty. Entanglement – the quintessence of quantum world – can be exploited to enhance the interferometric sensitivity beyond the limitation of classical technologies and approach the fundamental bound imposed by quantum theory [**1**]. Quantum Fisher information has recently come to the fore as a useful detector of entanglement among particles for applications in quantum interferometry [**2**]. Surprisingly, it is also revealing to be a useful tool for other tasks, such as detecting quantum phase transitions. We will introduce the general concepts and briefly discuss some remarkable experimental schemes, with particular reference to ultracold atomic systems [**3**].

[**1**] V. Giovannetti, S. Lloyd and L. Maccone, *Science* **306**, 1330 (2004)

[**2**] L. Pezzè and A. Smerzi, *Quantum theory of phase estimation*, in G. M. Tino and M. A. Kasevich, "Atom Interferometry. Proceedings of the International School of Physics Enrico Fermi", IOS Press (2014)

[**3**] A. Trenkwalder *et al.*, *Nature Physics* **12**, 826 (2016)