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Type: **Talk**

## **Matter waves exposed to the external world: Decoherence, gravity, complementarity and time irreversibility**

*Wednesday 23 August 2017 17:30 (30 minutes)*

Matter-wave interferometry provides an excellent tool for probing the environment and studying its coupling to isolated atoms. We will present several interferometry experiments done with a BEC on an atom chip [1] and in which different effects of the environment have been investigated. First, we will discuss fluctuations in the nearby environment probed by an interference of atoms trapped in a magnetic lattice very close ( $5\mu\text{m}$ ) to a room temperature surface [2,3]. Here an order-of-magnitude improvement has been obtained over previous atom-surface distances for which spatial interference has been observed. Next, we will present a new interferometry of self-interfering clocks and show, in a proof-of-principle experiment, how it could probe the interplay of QM and GR [4]. We will also describe a rule for “clock complementarity”, which we deduce theoretically and verify experimentally [5]. Finally, we will discuss Stern-Gerlach interferometry [6] and describe it in the context of time irreversibility [7]. To the best of our knowledge, this is the first time spatial Stern-Gerlach interferometry has been realized, and we analyze our data in the context of previous theoretical work relating the difficulties in realizing Stern-Gerlach interferometry to time irreversibility.

[1] Mark Keil, Omer Amit, Shuyu Zhou, David Groswasser, Yonathan Japha, Ron Folman, “Fifteen years of cold matter on the atom chip: Promise, realizations and prospects”, *Journal of Modern Optics* 63, 1840 (2016).

[2] Shuyu Zhou, David Groswasser, Mark Keil, Yonathan Japha, Ron Folman, “Robust spatial coherence  $5\mu\text{m}$  from a room temperature atom-chip”, *Phys. Rev. A* 93, 063615 (2016).

[3] Yonathan Japha, Shuyu Zhou, Mark Keil and Ron Folman, Carsten Henkel, Amichay Vardi, “Suppression and enhancement of decoherence in an atomic Josephson junction”, *New J. Phys.* 18, 055008 (2016).

[4] Yair Margalit, Zhifan Zhou, Shimon Machluf, Daniel Rohrlich, Yonathan Japha, Ron Folman, “A self-interfering clock as a ‘which path’ witness”, *Science* 349, 1205 (2015).

[5] Atom Chip group, “Clock complementarity in the context of general relativity”, in preparation.

[6] Shimon Machluf, Yonathan Japha and Ron Folman, “Coherent Stern-Gerlach momentum splitting on an atom chip”, *Nature Communications* 4, 2424 (2013).

[7] Atom Chip group, “Probing the emergence of the arrow of time with a high visibility Stern-Gerlach interferometer”, in preparation.

### **Topic:**

Topic: Quantum Physics, Quantum Optics and Quantum Information

### **Summary**

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