

**Speaker: Alexa Herter (ETH Zurich)**

**Title: Revisiting Fermi's two-atom problem with an experimental simulation**

**Place: Seminar room 915**

### **Revisiting Fermi's two-atom problem with an experimental simulation**

During the development of the quantum theory of light, Fermi studied the propagation of light in vacuum with two atoms probing the electromagnetic field [1]. He investigated the correlation of the atoms caused by the exchange of a photon and concluded: The atoms will show purely causal correlations arising only after the time of flight of the photon has passed. However following theoretical studies revealed correlations occurring already before the atoms could have exchanged a photon. As we know today, these non-causal correlations are induced by the ground state fluctuations of light. Recently we presented an experiment simulating Fermi's two-atom problem by ultra-short laser pulses interacting with the ground state of light, where we demonstrated vacuum-induced correlations in the non-causal regime [2].

However, effects typically related to vacuum fluctuations, such as spontaneous emission or the Lamb shift, cannot be caused purely by the ground state of light. A second effect – the so called radiation reaction – is crucial for a conclusive quantum description of light-atom interaction. Though separating the contribution of radiation reaction and vacuum fluctuations was so far limited to the theoretical discussions [3].

Now we want to explain, why the correlations in our experiment are related only to vacuum fluctuations. At the same time we show how a slight modification of the detection scheme allows to observe the correlations arising from the radiation reaction [4]. The latter are of purely causal nature and therefore relate to the initial picture described by Fermi [1].

[1] E. Fermi "Quantum Theory of Radiation." Rev. of Mod. Phys. 4 (1932)

[2] F. F. Settembrini, et al. "Detection of quantum-vacuum field correlations outside the light cone." Nature Com. 13 (2022)

[3] J. Dalibard, J. Dupont-Roc, C. Cohen-Tannoudji "Vacuum fluctuations and radiation reaction: identification of their respective contributions." Journal de Physique 43 (1982)

[4] F. Lindel, et al. "How to Separately Probe Vacuum Field Fluctuations and Source Radiation in Space and Time" preprint: <https://arxiv.org/abs/2305.06387>