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Observation of Multimode strong coupling of laser-cooled atoms to fiber-guided photons — •Martin Blaha[1], Aisling Johnson[1], Alexander Ulanov[2], Jürgen Volz[1], Philipp Schneeweiss[1], and Arno Rauschenbeutel[3] — [1]TU Wien, 1020 Wien, Austria — [2]Russian Quantum Center, 143025 Moscow, Russia — [3]Humboldt-Universität zu Berlin, 10099 Berlin, Germany

We report on the observation of multimode strong coupling between a cloud of cold atoms and a nanofiber-based fiber ring resonator. This novel regime of light-matter coupling is reached when the collective coupling strength between a cloud of laser-cooled Cesium atoms and the light field exceeds the free spectral range (FSR) of the resonator, leading to strong coherent coupling of the atoms with more than one longitudinal resonator mode simultaneously [1]. The mode cross-section of our resonator containing an optical nanofiber is independent of its length, such that using a 30 m long fiber ring resonator yields an exceptionally small free spectral range of 7.1 MHz, while at the same time having large collective coupling strengths [2]. The measured transmission spectra provide clear experimental evidence for multimode strong coupling of the loaded cavity, yielding coupling strengths as large as twice the FSR. In this regime of cavity QED atoms can mediate interactions between photons in different resonator modes, through which we envision to employ for the generation of novel non-classical photonic states.

[1] D. Meiser et al., Phys. Rev. A 74, (2006).
[2] P. Schneeweiss et al., Opt. Lett. 42, (2017).

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Email:	**martin.blaha@tuwien.ac.at**