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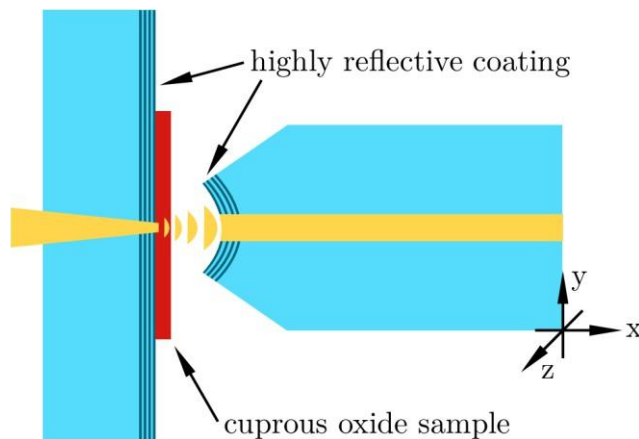
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## High-resolution study of Rydberg exciton-polaritons in Cu<sub>2</sub>O using an open fiber cavity

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Excitons represent one of the most fundamental excitations in semiconductors. Analogous to hydrogen atoms, electron and hole can occupy different orbitals characterized by a principal quantum number  $n$ . In 2014 excitations with a principal quantum number of  $n = 25$  were experimentally demonstrated in Cu<sub>2</sub>O [1]. Those so called **Rydberg excitons** have unique properties such as long lifetimes, large spatial extent and strong mutual interactions and have therefore been considered promising candidates for future quantum technologies since their first discovery. Recent research has further highlighted this potential by demonstrating the formation of Rydberg exciton-polaritons via strong light-matter coupling in a microcavity, which additionally exhibit nonlinear interaction dynamics [2][3].



**Fig. 1:** Schematic illustration of the resonator

Here we present an **open fiber cavity platform** (Qlibri Quantum, Qlibri GmbH), which allows us to reach the strong coupling regime of Rydberg exciton-polaritons in Cu<sub>2</sub>O up to a principal quantum number of  $n = 12$ . As shown in Fig. 1, the fiber can be positioned in all three spatial directions, allowing us to investigate the influence of parameters such as the sample position or the cavity length on the coupling strength. In addition, a second laser can be coupled into the cavity to study nonlinear Rydberg blockade effects between different exciton-polaritons.

- [1] T. Kazimierczuk, D. Fröhlich, S. Scheel, H. Stolz, and M. Bayer, Giant Rydberg excitons in the copper oxide Cu<sub>2</sub>O. *Nature* **514**, 344 (2014).
- [2] Orfanakis, K., Rajendran, S.K., Walther, V. et al. Rydberg exciton-polaritons in a Cu<sub>2</sub>O microcavity. *Nat. Mater.* **21**, 767–772 (2022).
- [3] Makhonin, M., Delphan, A., Song, K.W. et al. Nonlinear Rydberg exciton-polaritons in Cu<sub>2</sub>O microcavities. *Light Sci Appl* **13**, 47 (2024).