# Clock Spectroscopy on the Ionic Core of Alkaline-Earth Circular Rydberg Atoms

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Highly excited Rydberg atoms are a platform for quantum simulation and computing. However, their natural lifetimes display a limit of the coherence times. We drastically increase the lifetimes of the Rydberg states by exciting neutral $^{88}$Sr atoms to long-lived circular Rydberg states (CRS). At maximum angular momentum, no optical decay channels exist. Moreover, black-body induced decay can be suppressed using a resonator made from indium tin oxide [1]. This results in CRS with lifetimes in the millisecond-range, even at room temperature [2]. A microwave (MW) qubit encoded in two CRS combines the enhanced lifetimes with the key properties of Rydberg states for quantum simulation, but is not locally controllable in a tweezer array.

In the case of the alkaline-earth species $^{88}$Sr, the excitation of one valence electron to the CRS exposes the other valence electron near the core. The optically active core provides access to a range of new tools – such as trapping and local control of the CRS. Especially, quantum logic spectroscopy of the narrow clock transition, $^2S_{1/2}$ - $^2D_{5/2}$, allows for local control and readout of the MW qubit due to the quadrupole coupling between the electron in the CRS and core electron in the $^2D_{5/2}$-state [3]. In my contribution, I will focus on our experiments exploring the quadrupole coupling and reporting coherent control of the optical qubit of the ionic core inside a CRS.

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[3] M. Wirth *et al.*, *Phys. Rev. Lett.* **133**, 123403 (2024).

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