

FAKULTÄT für PHYSIK  
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MÜNCHEN/GARCHING

PHYSIK-DEPARTMENT  
TECHNISCHE UNIVERSITÄT MÜNCHEN  
MÜNCHEN/GARCHING

## Garching Maier-Leibnitz-Kolloquium

Donnerstag, 21.01.2021, 16<sup>15</sup> Uhr

Online via ZOOM:

<https://lmu-munich.zoom.us/j/98457332925?pwd=TWc3V1JkSHpyOTBPQVlMelhuNnZ1dz09>

Meeting ID: 984 5733 2925

Passcode: 979953

**Prof. David Leibrandt**

(NIST and University of Colorado, Boulder, USA)

### Quantum logic and precision measurements with atomic and molecular ions

The tools of trapped-ion quantum logic can be used to enable and enhance precision measurements, with applications in time and frequency metrology and the search for physics beyond the standard model.

In this talk, I will cover three experiments at this fertile intersection of fields. I will begin with a description of optical atomic clocks based on  $\text{Al}^+$ , which use quantum logic with a co-trapped second ion species for preparation and readout of the  $\text{Al}^+$  state, and offer the tantalizing prospect of Heisenberg-limited measurements with entangled ions. Recent experimental progress includes fractional systematic uncertainty below  $10^{-18}$ , spectroscopic coherence times up to 8 s, frequency ratio measurements between  $\text{Al}^+$ ,  $\text{Sr}^+$ , and  $\text{Yb}^+$  clocks with total uncertainty below  $10^{-17}$ , and new constraints on models of ultralight dark matter. Next, I will briefly describe an experiment in which quantum-logic readout is used to prepare pure rotational and hyperfine states of a single  $\text{CaH}^+$  ion, and the frequencies of THz rotational transitions are measured with sub-100-Hz resolution. Our methods can be extended to study rotational and vibrational transitions of a large class of diatomic and polyatomic molecular ions that are useful in the search for new physics.

Finally, I will conclude with a preview of a new experimental effort aimed at laser excitation of the  $^{229}\text{Th}^{3+}$  nuclear isomer transition, which has orders of magnitude enhanced sensitivity to physics beyond the standard model in the QED and QCD sectors.

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