Limits and Requirements for the Qualification of spaceborne Rydberg Quantum sensors

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Abstract: This presentation will highlight the effort required for translating a quantum technology such as a Rydberg antenna into a miniaturized ultra-sensitive and very wideband microwave sensor that can be applied in novel spaceborne RF payloads.

By means of quantum technology, ultra-sensitive and very wideband microwave sensors can be envisaged, which could pave the way to novel spaceborne RF payloads and microwave remote sensing instruments targeting applications such as earth observation, science and telecommunications. A key example for such sensors are Rydberg antennas, based on the simultaneous illumination of an alkaline vapour (such as Rb or Cs) with optical and microwave signals, with the latter affecting the reading of the optical signal through the Autler-Townes splitting.

A crucial step toward enabling real-world applications for quantum sensing devices is reducing their size, weight, power, and cost (SWaP-C) requirements without significantly reducing performance. Laser frequency stabilization is a key part of many quantum sensing devices and, when used for exciting non-ground state atomic transitions, is currently limited to techniques that require either large SWaP-C optical cavities and electronics or use significant optical power solely for frequency stabilization. Such configurations are not compatible with the complex space environment, where SWaP requirements are complicated by the automation needs and reliability to extreme conditions, such as mechanical and thermal stress, radiation exposure, and long lifetimes.

This presentation will highlight the effort required for translating a quantum technology such as a Rydberg antenna into a miniaturized sensor that can be applied in novel spaceborne payloads for applications in Multifrequency Microwave Radiometry and synthetic aperture radars (SAR) for earth observation, or ultrasensitive wideband antennas for telecommunication. Key requirements for laser and vapour cell stability and integration will be highlighted, with a focus on the thermo-mechanical and radiation exposure limits required for increasing the technological readiness level of the sensors and the qualification for future payloads at low earth orbit.