Compact optical frequency standards and vapor cell clocks in space

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Frequency stabilized laser systems are one of the key elements in precision experiments based on atom interferometry and optical clocks with applications in navigation, timing and sensing. Future space missions for next generation gravity mapping, tests of the equivalence principle, detection of gravitational waves and improved global positioning systems require laser systems that are robust, compact and reliable.

Absolute optical frequency references using vapor cells nowadays achieve sufficient accuracy and precision, which makes them suitable candidates for above mentioned applications in space. The payloads FOKUS [1] and KALEXUS [2] successfully demonstrated key technologies for optical frequency references on sounding rockets based on rubidium and potassium vapor cells.

With our latest payload JOKARUS [3], we have realized an autonomous, absolute optical frequency reference using hyperfine transitions in molecular iodine at 532 nm which is scheduled for launch in May 2018. Here, we apply modulation transfer spectroscopy on a quasi-monolithic spectroscopy module with an unsaturated iodine cell.

In order to close the gap between sounding rockets and orbital deployment, we are currently developing a frequency reference employing the rubidium $^5S_{1/2}$ - $^5D_{5/2}$ two photon transition at 778nm [4,5] and investigate the means of implementation on a small satellite.

In this poster, we will give an overview on our recent payloads and developments of optical frequency standards, and discuss the prospects of future compact thermal beam spectroscopy setups for alkaline earth atoms.

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[1] M. Lezius, et al. Space-borne frequency comb metrology, Optica 3, 1381-1387, (2016).

[2] A. N. Dinkelaker, et al. Autonomous frequency stabilization of two extended-cavity diode lasers at the potassium wavelength on a sounding rocket, Appl. Opt. 56, 1388-1396 (2017).

[3] V. Schkolnik, K. Döringshoff, et al. JOKARUS - design of a compact optical iodine frequency reference for a sounding rocket mission, EPJ Quantum Technol. 4: 9 (2017)

[4] M. F. Barschke, et al. Optical Quantum Technology in Space using Small Satellites, IAC-17,B4,2,9,x39017. (2017)

[5] Daniel K. L. Oi, et al. Nanosatellites for quantum science and technology, Contemporary Physics, 58:1, 25-52 (2016)