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OPTICAL FREQUENCY REFERENCES FOR SPACE APPLICATIONS

Abstract

Optical frequency references are a key technology for future space missions in fundamental physics, geoscience, Earth observation and navigation and ranging. Examples are the gravitational wave detector LISA (Laser Interferometer Space Antenna), the Earth gravity mission NGGM (Next Generation Gravity Mission) and missions testing Special Relativity such as BOOST (Boost Symmetry Test). Furthermore, future GNSS (Global Navigation Satellite Systems) will benefit from optical frequency references with higher performance in frequency stability, compared to the currently used microwave clocks.

We present our work on the development of frequency references based on Doppler-free spectroscopy of molecular iodine where special emphasis is put on compactness and robustness for space operation. We realized a setup on elegant breadboard level (EBB) on a 55cm x25cm thermally and mechanically stable glass-ceramic base plate using a 30 cm long iodine cell in triple pass configuration [1] and a more compact system on engineering model level (EM) [2] using a specifically designed compact iodine cell in 9-pass configuration on a 38cm x18cm fused silica base plate. Both setups show similar frequency stabilities at the 10-15 level at integration times between 10s and 1000s. The EM setup was subjected to thermal cycling and vibrations. In a recent activity, a spectroscopy unit for use on a sounding rocket mission has been developed and integrated [3].

Further steps with respect to space operation are presented, including mission proposals for testing special relativity and for technology demonstration of optical clock technologies for future GNSS.

[1] T. Schuldt, K. Döringshoff, E. Kovalchuk, A. Keetman, J. Pahl, A. Peters, C. Braxmaier, “Development of a compact optical absolute frequency reference for space with 10-15 instability”, Applied Optics, vol. 56, p. 1101-1106, 2017.

[2] K. Döringshoff, T. Schuldt, E.V. Kovalchuk, et. al., A flight-like absolute optical frequency reference based on iodine for laser systems at 1064 nm", Appl. Phys. B 123: 183, 2017.

[3] V. Schkolnik, K. Döringshoff, F.B. Gutsch, et al. JOKARUS – design of a compactoptical iodine frequency reference for a sounding rocket mission“, EPJ Quantum Technol. 4:9, 2017.