Design of a satellite rubidium two-photon frequency reference for the CRONOS payload

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Optical frequency standards based on two-photon spectroscopy using hot rubidium vapor are a promising candidate for realization of simple and compact optical clocks for e.g. application in next generation global navigation satellite systems. In this contribution, we present the development and design of such a small and rugged frequency reference aimed at deployment on a small satellite in low-earth orbit. It is operating on the Doppler-free $5S_{1/2} \rightarrow 5D_{5/2}$ two-photon transition in rubidium. An extended cavity diode laser operating at 778.1 nm is stabilized to this reference using FM spectroscopy by detection of a 420.3 nm decay path. The SWaP budget (size, weight and electrical power) of the reference prototype encompass approximately < 0.6 L of volume, < 900 g of mass and less than 1 W of total power consumption. Considerations with respect to thermal, mechanical, and magnetic envelopes, as well as their evaluations will be highlighted with additional information on remedial actions taken. Further details on the QUEEN mission, the satellite bus, and the clock payload CRONOS are provided as well. We aim for a fractional frequency instability of $\sigma_y \approx 10^{-13}\,\tau^{-1/2}$ on ground and in-orbit performance of $< 3 \times 10^{-12}\,\tau^{-1/2}$ with long-term minimum instability values in the order of 10^{-15}.
This work is supported by the German Space Agency (DLR) with funds provided by the Federal Ministry for Economic Affairs and Climate Action (BMWK) due to an enactment of the German Bundestag under grant numbers 50RK1971, 50WM2164.

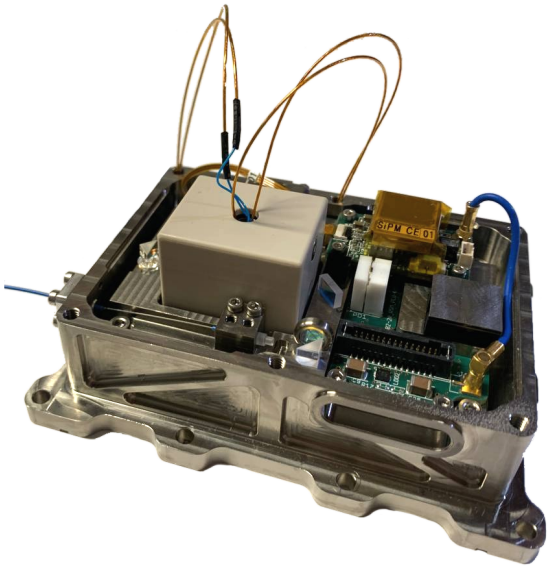

Figure 1. Photo of the prototype optical two-photon frequency reference for the satellite mission which is currently being assembled and integrated.