Compact and Transportable Iodine-Stabilized Laser for the LISA Space Mission Ground Tests

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The French activities for the LISA (Laser Interferometer Space Antenna) mission include the assembly, integration, validation, and testing of the payload by a consortium of several partners led by CNES. SYRTE has been developing a laser activity for various tests and interferometric measurements carried out by the consortium for several years. A partnership with eXail has led to a significant technological advancement in the maturation and development of a reference laser stabilized on iodine. This frequency-stabilized laser setup is compact and transportable over several hundred kilometers and does not require any realignment after transport. The entire laser setup consists of two Nd:YAG lasers operating at the nominal wavelength of LISA at 1064.49 nm. These two lasers are phase-locked to each other and to a telecom reference laser at 1596.7 nm, which is frequency-stabilized over a hyperfine transition of iodine vapor at 532.245 nm. The frequency gaps between the infrared and the green ranges are bridged using second-harmonic generation and third-harmonic generation. The spectroscopic bench for iodine interrogation is very monolithic and does not need any realignment after transport. The complete configuration has been defined using the metrological frequency chain of the LNE-SYRTE Laboratory, ensuring that the LISA Mission specifications were met before conducting interferometric measurements. These characterizations have enhanced SYRTE's ability to accurately assess lasers with a linewidth ranging from 10Hz to 1kHz. The laser setup was successfully transported by road from SYRTE-Observatoire de Paris to LAM-Marseille in July and brought to nominal operation in just 1 hour. It has been used over several weeks for high-precision interferometric measures without any intervention. The preliminary analysis of the interferometric measurements, each lasting for several hours, yielded promising results above the LISA Mission specifications for ground tests. Especially in the high-frequency band where the residual noise of the laser is predominant. In conclusion, the French contributions to the LISA mission involve the development and successful operation of a sophisticated laser system by SYRTE in collaboration with CNES and eXail. This compact and transportable setup, stabilized on iodine, demonstrated exceptional stability and precision during high-precision interferometric measures. Thorough characterizations at the LNE-SYRTE Laboratory confirmed compliance with mission specifications, and the system's successful transport and rapid nominal operation underscore its robustness. The preliminary analysis of interferometric measurements revealed outstanding results, exceeding mission specifications for ground tests.