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2. Article : The Galileo Iodine clock (Poster)

3. Conference: EFTF 2026, the European Frequency and Time Forum (EFTF).

Already approved according to the D/NAV Conference Planning of the current year: YES

4. Journal : not applicable

COST INVOLVED : NO

Estimate : Authors signature Date

5. Approval of Procurement Manager (if applicable) Signature Date
6. Approval of Head of Navigation Security Office Signature Date
7. Decision of Department Head Publication agreed / not agreed Signature Date
As per the new security directive (section 4.1.2.4 ESA UNCLASSIFIED – Releasable to the Public, paragraph 3) ***A written record of the delegation of authority to decide whether information may be released to the public shall be kept within each Directorate. It's the responsibility of the Director concerned to set up this process***. 8. Decision of Director : Publication agreed / not agreed Signature Date

The Galileo Iodine Clock

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Introduction

An optical iodine-based clock is being developed within the Galileo/ EGNOS Upstream Research and Development Programme under Horizon Europe. Atomic and molecular reference transitions enable compact, high-performance optical clocks and pave the way for next-generation frequency standards in satellite navigation. With this development, we aim to bring optical clock technology onto future Galileo satellites.

The Galileo iodine optical clock uses a molecular-iodine transition that provides narrow, long-term stable and environmentally robust spectral features at room temperature, making it a well-established reference for laser frequency stabilization.

The clock is specifically engineered to withstand the mechanical stresses encountered during launch and to operate reliably under vacuum conditions. The overall design is based on Class 1 electronics, and a full qualification campaign is planned.

Figure 1: Design of GIC with two independent units, the Iodine Reference Unit (right) and the Frequency Comb (left)

Performance

The system is designed in a compact form factor to meet the Size Weight and Power (SWaP) constraints imposed by the satellite. A long-term stability on the order of $<1\times10^{-13}/\sqrt{\tau}$ and a daily performance level in the low 10^{-15} range is targeted. Breadboard measurements of both the spectroscopy setup and the frequency comb demonstrate performance consistent with these objectives.

Design

The system consists of two main units: the Iodine Spectroscopy Unit built by STI and a fiber-based frequency comb from Menlo Systems. In the spectroscopy module, the micro-integrated diode laser from FBH is stabilized to a transition in iodine vapor using Doppler-free modulation-transfer spectroscopy. This stabilized optical signal is transferred to the RF domain via the frequency comb which is phase-locked to the stabilized laser. By dividing the optical frequency, the comb generates a highly stable microwave clock signal which is delivered to the satellite's clock-monitoring unit.

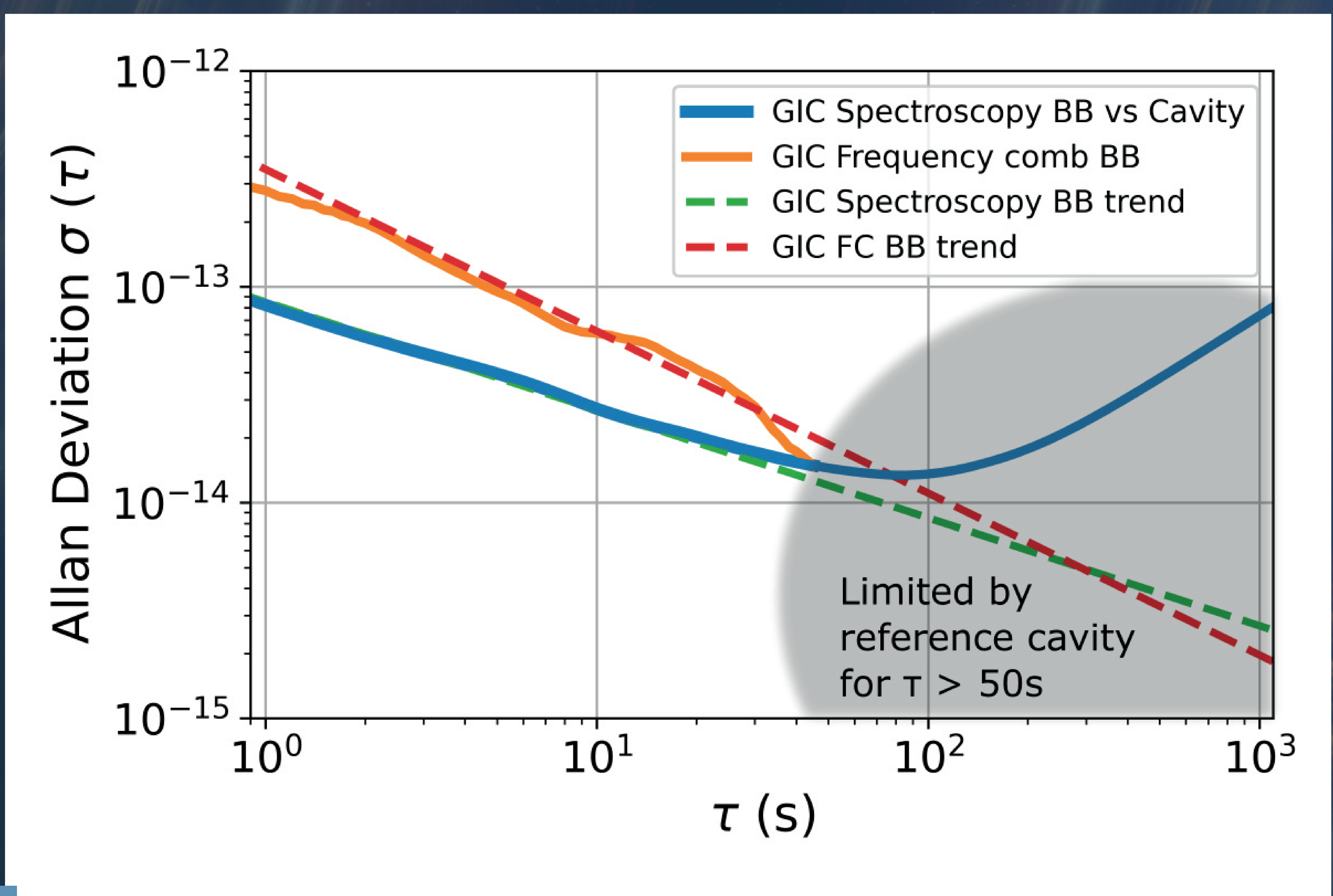

Figure 2: Estimated performance based on measurement of the spectroscopy breadboard and the space comb of Menlo Systems

Figure 3: Image of the micro integrated Laser Module from FBH

Next Steps

The project is currently in the engineering model phase and aims to deliver an engineering qualification model (EQM) and an experimental flight model (exp FM) for integration into a second generation Galileo satellite.

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