SUPPRESSED NOISE OSCILLATORS

Key Benefits:

- Developed the lowest phase noise oscillators in the world,
- Useful for precision and quantum sensing, 5G telecommunications and radar.
- Implemented the low noise oscillator as a high precision sensor for an optomechanical gravity gradiometer.
- Technology licenced to Lockheed Martin Corporation (LMC), who provide the only commercially available gravity gradiometers.
- Licence allows a provision to collaborate with Australian Defence Forces for military applications.
- The UWA design is, less expensive, compact for use on drones and unmanned carriers. Could allow detecting voids, tunnels and underground structures.

Background

Ultra-low phase noise oscillators are important devices for controlling the spectral purity for a range of military and industrial applications, including high-resolution Doppler radars and secure communication networks. In particular they are now important for operation of 5G networks. Also experiments on fundamental physics and the study of quantum behavior of macroscopic objects have significantly improved with the development of low noise oscillators. Many companies exist that specialize in such oscillators, including quartz oscillators, YIG oscillators, and high-Q cryogenically cooled sapphire oscillators

Also, low noise oscillators are important as part of a read out for high sensitivity transducers. In the past they have been used for gravitational wave detection, an acoustic system coupled to a high Q cavity, excited by a low phase noise oscillator, made with a high sensitivity to gravitational waves. Similarly we can implement low noise oscillators for sensitive quantum and gravity measurements, in our case we implement a patented scheme sensitive to gravity gradients.

Technology

Microwave oscillators with very low level of phase fluctuations have been constructed based on the principles of Interferometric Signal Processing (ISP). Such oscillators require a few Watts of electric power to operate, less noisy, cheaper and more compact than commercial microwave frequency synthesizers. On the other hand, the ISP oscillators are not as widely tunable as frequency synthesizers. Yet for a number of applications the frequency agility is not of primary importance. Thus, the adaption of this technology for specific needs in communication and sensing can give a significant advantage. One particular application of this kind includes a field-deployable gravity gradiometer which is of interest to exploration and mining companies

Translation project

The project consistent of designing high-Q resonators for the frequency determination element in a low noise oscillator, or as a sensitive transduction element, and coupling low-noise photons to an acoustic sensing element. An example of a high-Q sapphire resonator is shown in Fig. 1, and a high sensitivity re-entrant cavity displacement sensor coupled to a ribbon acoustic sensor shown in fig. 2. The low-noise oscillator is shown in Fig.3.

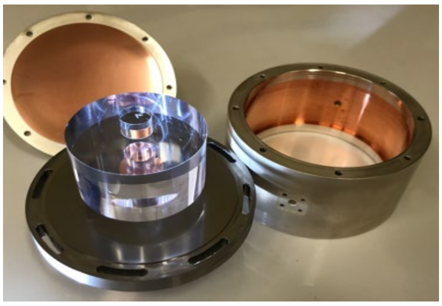

Fig. 1. High-Q sapphire Cavity.

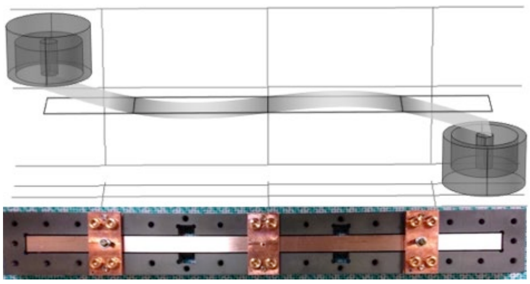

Fig. 2. Displacement of ribbon gravity gradient sensor coupled to re-entrant microwave cavities.

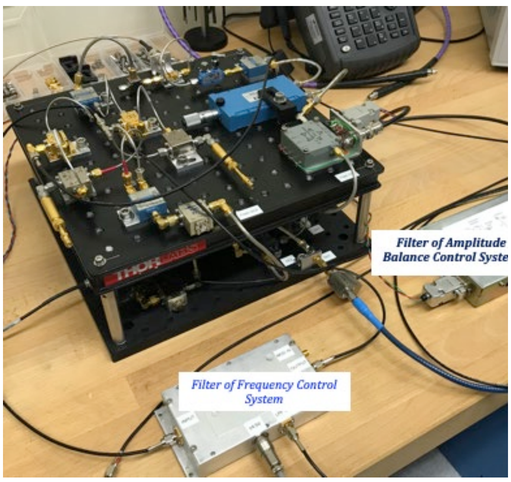

Fig. 3. Low noise oscillator based on microwave interferometry.

Outcomes

There were two major outcomes. 1) The measurement of low phase noise from a microwave oscillator as shown in Fig.4 [1]. 2) The development of a sensitive gravity gradiometer in the lab, with results shown in fig. 5.

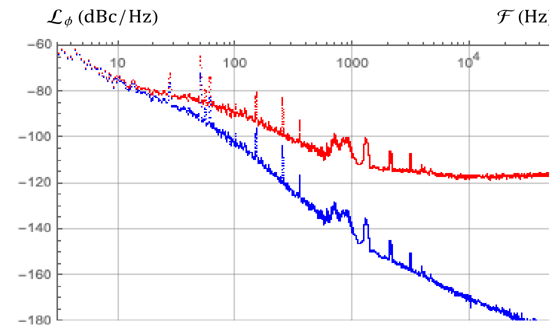

Fig. 4. SSB phase noise spectra of the E8257D at 11.2 GHz: top trace – measured phase noise of the incident signal; bottom trace is the inferred phase noise of the transmitted signal.

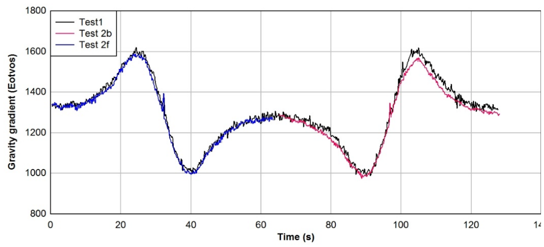

Fig. 5. The gravity gradient signal along the Ribbon Sensor is estimated to be about 280 Eötvös peak (or 560 p-p) from this response to a lead test pass passing underneath.

Future opportunities

There is an opportunity to develop these type of oscillators for Defence and 5G applications. We have interest from companies such as Cryo-Clock and some specific 5G companies. Another opportunity is to use them as part of a high precision sensor, and we have engaged with Lockheed Martin to build first the prototype of the gravity gradiometer with success, and there is a possibility of engaging defense companies.

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Team

The University of Western Australia (UWA) team consists of Alexey Veryaskin, Michael Tobar (team leader) & Eugene Ivanov, inventors of the patented Taipan Intrinsic Gravity Gradiometer system (https://patents.google.com/patent/WO2018071993A1). Combined with group members that contributed, Jeremy Bourhill, Ben McAllister and Maxim Goryachev.

Alexey Veryaskin has deep expertise in gravity gradiometry spanning 35 years (www.trinitylab.net/people). Michael Tobar and Eugene Ivanov are core members of UWA's Quantum Technology and Dark Matter Laboratories, and are experts in precision sensing. Prof. Eugene Ivanov, designed all the resonators and oscillators, set up the experiments, while Mr. Steve Osborne the labs technician from the mechanical work shop built all hardware. Prof. Alexey Veryaskin, implemented the oscillator and resonator technology to read out the optomechanical gravity gradiometer.

[1] Eugene N. Ivanov and Michael E. Tobar, Noise Suppression with Cryogenic Resonators, submitted 2020.