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# Cold Atom Quantum Technology to Explore Fundamental Physics

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In this presentation, I will outline the scientific opportunities presented by a multi-stage programme based on cold atom quantum technology. The central objectives of this programme include the search for ultra-light dark matter, the exploration of gravitational waves in the mid-frequency range—specifically between the peak sensitivities of LISA and LIGO/Virgo/KAGRA/INDIGO/Einstein Telescope/Cosmic Explorer experiments—and the investigation of other frontiers in fundamental physics. This programme will complement other planned dark matter searches, probe mergers involving intermediate-mass black holes, and explore early-universe cosmology.

I will particularly focus on key activities in this field, such as the AION project in the UK and the international Terrestrial Very-Long-Baseline Atom Interferometry (TVLBAI) initiative, which is currently in the process of forming a proto-collaboration. The TVLBAI initiative aspires to establish a global network of large-scale atom interferometers designed to detect ultra-light dark matter and gravitational waves, with the ultimate aim of deploying kilometre-scale detectors by the mid-2030s. This collaboration is dedicated to developing a comprehensive roadmap, which will outline the scientific and technological milestones essential for the success of these groundbreaking detectors.

### Relevant References:

- AION Collaboration. (2020). “AION: An Atom Interferometer Observatory and Network.” *Journal of Cosmology and Astroparticle Physics*, 2020(05), 011. arXiv:1911.11755
- Abend, S., et al. (2024). “Terrestrial Very-Long-Baseline Atom Interferometry: Workshop Summary.” *AVS Quantum Science*, 6(2), 024701. arXiv:2310.08183
- Abdalla, A., Abe, M., Abend, S., et al. (2025). “Terrestrial Very-Long-Baseline Atom Interferometry: Summary of the Second Workshop.” *EPJ Quantum Technology*, 12(1), Article 42. <https://doi.org/10.1140/epjqt/s40507-025-00344-3>

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