Reduction of technical noises, vibration-rejection and acceleration sensitivity reduction in cryogenic Si optical resonators.

Ultrastable optical resonators such as Fabry-Perot Cavities (FPCs) highly benefit from cryogenic temperature operation, which lowers the thermal noise. Single-crystal Si exhibits both high-mechanical quality factors and thermal expansion coefficient cancellations at specific temperatures (124 K and 17 K). Reducing the temperature below 1 K grants simultaneously a further reduction in thermal noise and a vanishing thermal expansion coefficient for single-crystal Si.

Several proof-of principle cryogenic FPC experiments have paved the way for short-term fractional frequency stabilities in the low 10^{-17} range with low frequency drift. The drawbacks of cryogenic operation are the use of costly coolants such as helium as well as the vibrations introduced by the cryo-cooler to the resonator. Liquid helium or nitrogen baths are particularly problematic, as the frequent re-fills interrupt the frequency reference operation, and drastically increase the cost of the experiment.

The PhD thesis will investigate the behaviour of these systems, and develop and implement methods that allow cryogenic cooling without degrading the performance of the reference systems. Cryogen-free closed cycle cryostats have the prospect for low maintenance operation over many months but create strong vibrations. Thus, sophisticated passive vibration-isolation methods will be implemented, that are compatible with the requirements of the reference resonators.

The proposed PhD subject will be related to the European EMPIR NEXTLASERS project, which involves both PTB and FEMTO-ST, among other European institutes. The candidate will investigate technical noises and fundamental limits in cryogenic Si FP cavities, working first at FEMTO-ST at temperatures below 1 K, and at PTB at the temperature inversion point at 124 K. The study will involve passive and active reduction of temperature and vibration sensitivities, employing complementary approaches from FEMTO-ST and PTB, in order to enable reaching the fundamental limit of such cavities in the low 10^{-17} range. A special emphasis will be put on the measurement and rejection cryostat-induced vibrations, which is a common problem to both setups.