The POLIS interferometer for ponderomotive squeezed light generation

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POLIS is a suspended interferometer, presently under construction, devoted to the generation of ponderomotive squeezed light and to the study of the interaction of non classical quantum states, of light, and macroscopic objects. The interferometer is a Michelson whose half-meter long arms are constituted by high-finesse cavities, suspended to a seismic isolation chain similar to the Virgo Super Attenuator. The mass of the suspended cavity mirrors are chosen to be tens of grams: this value is sufficiently high to permit the use of the well tested Virgo suspension techniques but also sufficiently small to generate the coupling among the two phase quadratures with a limited amount of light in the cavity, of the order of few tens of kW. In this poster, the main features of the interferometer are shown, together with the expected sensitivity and squeezing factor.

What is interesting in ponderomotive squeezing?

Squeezing generation in MOEMS (Micro-Opto-Electro-Mechanical Systems) – Communication and integrated sensors; on chip devices OPO integration in the well consolidate silicon technology (travised technology with KTP and LBO on Si) is more expensive and does not allow the same integration factor.

Study of the coupling between macroscopic opto-mechanical objects and their quantum mechanical behavior – Theoretical interest

Low frequencies and frequency independent squeezing – GEO detectors

PS is a completely suspended system: we expect that could be, in a regime a more robust system in long period operation OPO squeezed seem experimetal work is limited due to lsses mechanism in the medium (photo-thermal fluctuations) even if progress in material engineering and dedicate mechanical design promises to overcome these limits.

Polis Optical Parameters

Parameters value optimization

A large enough squeezing factor and the desired frequency band

Cavity detuning: trade-off between squeezing value and band

High level increases band Low level increases squeezing

By changing the losses, this assures more than 20 dB of potential squeezing delivered by the interferometer

Ps=2.5 W F ≤ 300 kHz

Constraints for the cavity length: inner cavity diameter L = 480 mm

In the cavities, the inner walls are flat squeezed mirror are needed to control the angular instability

γ ≈ 0.76

Available quality factors for different commercial substrates

RCP=30 mm

This value of the RCP becomes the minimum spot size, ε0 in the mirror with the available commercial coating:

(longitudinal coherence length of the coating)

Qualitative view of γ ≤ 0.76 L/2mm KTP (in mm)

by controlling the coupling with thermal deformations or imperfections, the cavity resonance and the higher order noise elements

Use of SAFE to high sensitivity in the low frequency range thanks to better atomic source

We can choose slightly higher

The expected noise is within the requirements, as shown in figures

Ponderomotive Light Squeezing POLIS project

Project to realize a completely suspended low frequency quantum squeezed light interferometer, moving from the pioneers’ work made in the LIGO laboratory at the MIT (Corbitt et al. Phys. Rev. A 73 (2006), 032301) and taking the advantage of the available Virgo Super Attenuator Facility at EGO, SAFE to control the main noise sources in the low frequency range

Critical Points

Ponderomotive Squeezing: large squeezing values without use high laser power and/or very high cavity finesse

very small suspended mirrors mass

very critical point is the mass compensation

Chance of success for the project

A relative large mass allows us to use the available well consolodated technologies of Virgo to control the low frequency noise

higher chance of success

Macroscopic squeezed states reduce the thermal noise

Reference


Frontier Detectors for Frontier Physics

13th Pisa Meeting on Advanced Detectors

10-13 May 2016 – La Biottola, Isola d’Elba (Italy)