

Frequency Independent Squeezing in Advanced Virgo

Marco Vardaro

March 15, 2019

Abstract

Quantum noise that limits Gravitational-wave (GW) interferometers, in the form of shot noise and quantum radiation pressure, is ultimately due to the interaction of the main laser field with quantum vacuum fluctuations that enter the instruments through the "dark" output port. A key towards better sensitivity in GW detectors is to suppress the quantum noise. One way to improve the sensitivity of GW detectors, without minimal modification to their optical configuration, is to inject squeezed vacuum states through the dark port.

Squeezed vacuum states are special quantum states of the electromagnetic fields in which quantum vacuum fluctuations, rather than being equally distributed among the two quadratures that describe the EM field, are reduced in one quadrature at the expense in the other. Which quadrature is chosen has a different effect on the observed level of shot or radiation-pressure noise. Such states can be generated by a nonlinear crystal via the Optical Parametric Amplification process (OPA). Injection of squeezed vacuum states through the interferometer dark port has been already demonstrated to effectively reduce quantum noise in the large-scale interferometric GW detectors GEO600, LIGO and more recently in Virgo.

The upgrade program of the Advanced Virgo detector foresees the injection of squeezed vacuum to reduce quantum noise. In a first phase (observing run 3, or O3), frequency-independent squeezed vacuum will be injected; in this case the "squeezed" quadrature is the same at all frequencies, leading to a decrease in the detector shot noise contribution at high frequencies while increasing, at low frequency, radiation pressure noise, which is however not yet a dominant contribution. The squeezing light source used for this purpose was developed by the AEI collaboration. I will present the main features and performance of the low-loss squeezed-vacuum injection subsystem and related controls system. Moreover the first Advanced Virgo long-term results related to the use of squeezed light will be discussed.

References

- [1] M. Mehmet and H. Vahlbruch, *Class. Quant. Grav.* 36, 015014 (2018)
- [2] FIS Squeezing Working group - Integration of the AEI squeezer in the Advanced Virgo detector - Technical Design Report (CRQ 2017/015) - VIR-0761B-17