ID de Contribution: **15** Type: **Non spécifié**

Non-degenerate low-loss recycling cavities for the gravitational waves detector Virgo

vendredi 5 décembre 2025 13:55 (25 minutes)

In this presentation, I present the optical design of the stable power and signal recycling cavities for the gravitational-wave detector Advanced Virgo+. First, I explain the importance of the stable cavities upgrade for improving the detector's control and noise performances. The optical design of the cavities is developed to fit within the limited infrastructure available at the Virgo site. Using FFT-based simulation tools, we fine-tune the design to minimize optical losses caused by astigmatism and spherical aberration. We then demonstrate that mirror radius-of-curvature errors can be compensated by adjusting the mirrors'positions. A similar technique is applied to correct for thermal effects in the Fabry–Perot cavity mirrors. Finally, we simulate the impact of mirror surface defects on the power recycling gain and signal recycling losses, showing that high gain and low losses can be maintained with the current polishing quality within some constraints on the mirrors'RMS. In addition, we introduce a new method to simulate losses effect on vacuum-squeezed states in the signal recycling cavity - an analysis that was previously not feasible. This technique provides new insights into critical losses to the squeezing system of Advanced Virgo+.

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Classification de Session: Instrumentation

Classification de thématique: Instrumentation