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Impact on Vacuum Requirements by Cryogenically Cooled Mirrors for Gravitational Wave Detection

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To reduce thermal noise and improve the sensitivity at low frequency, future gravitational wave detectors will use cryogenic mirrors. Cryogenically cooled mirrors present a number of extraordinary challenges, one being on the cryogenic vacuum system hosting the cold mirrors.
At cryogenic temperature, gases composing the residual vacuum will cryosorb and form a contaminant ice layer on the mirror surface. Such "frost"is known to be a significant bottleneck in operating cryogenic mirrors since, depending on the thickness, it may cause laser absorption and affect mirrors'optical properties. Stringent cryogenic vacuum conditions are, therefore, crucial to properly limit the ice growth. In fact, the adlayer characteristics (thickness and composition) depend on temperature and on the partial pressures of the different residual gas species composing the residual vacuum.
Here we estimate the ice layer growth rate for given conditions. This analysis sets new limits for an acceptable operating pressure to mitigate frost formation allowing long and continuous periods of data taking. Improving vacuum conditions, the ice growth can be certainly reduced, but not definitely avoided. Here we present a survey of potential mitigation methods to actively cure frost formation by thermal or non-thermal ice desorption from mirrors'surface.

Primary author: SPALLINO, Luisa (LNF)

Co-authors: ANGELUCCI, Marco (LNF); Dr PASQUALETTI, Antonio (European Gravitational Observatory (EGO),); BATTES, Katharina (KIT); DAY, Christian; GROHMANN, Steffen (KIT); MAJORANA, Ettore (ROMA1); RICCI, Fulvio (ROMA1); CIMINO, Roberto (LNF)

Presenter: SPALLINO, Luisa (LNF)

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