Contribution ID: **67** Type: **poster**

Gas cooling of test masses during observation runs

Wednesday, 19 May 2021 16:00 (1 minute)

The event rate of current observatories is partially limited by noise arising from temperature-driven position fluctuations of the test mass mirror surfaces used for probing space time dynamics.
Future gravitational-wave observatories address this limitation by using cryogenically cooled test masses; current approaches for continuously removing heat (resulting from absorbed laser light) rely on black-body radiation or conduction through suspension fibers.

As a complementing approach for extracting heat during observational runs,
we investigate cooling via helium gas impinging on the test mass in the free molecular flow regime.
We establish a relation between cooling power and corresponding displacement noise, based on analytical models, which
we compare to numerical simulations.
The application of our analytical models and numerical simulations is presented with regard to the conceptual designs of the Einstein Telescope and the Neutron Star Extreme Matter Observatory (NEMO).

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Session Classification: Poster session 1

Track Classification: Next detectors: Third generation design