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Balanced homodyne detection design and application at the 10m Prototype sub-SQL interferometer

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Quantum noise fundamentally limits the performance of ground-based interferometric gravitational wave detectors (GWDs).
The quantum nature of the light and its interaction with the interferometer defines the so-called interferometric standard quantum limit (SQL).
To further upgrade the GWDs sensitivities, as in the planned A+, VIRGO_nEXT, Einstein Telescope, and Cosmic Explorer, more complex, better-performing techniques will be required. In general, the SQL can be overcome with the application of quantum non-demolition techniques (QND).
One of the realizations of QND is known as Balanced Homodyne Detection (BHD).
In the context of GWDs, this technique requires suspended optical components.
This detail increases the technical challenges, such as the creation of a very stable local oscillator signal and the design of a more complex scheme to lock the interferometer at the dark fringe.
This adds to the requirements of the BHD, such as having strict BHD beamsplitter parameters and the further reduction of optical losses.
This presentation focuses on an overview of the relevant issues and solutions found for the implementation of a BHD using the Albert Einstein Institute (AEI) 10m Prototype sub-SQL interferometer. An optimal facility to study novel technologies for reaching and surpassing the SQL.
This will also include a report on the current progress towards realizing the interferometer and the current work in the application of a BHD scheme to achieve a direct sub-SQL measurement.

Primary author: CARLASSARA, Matteo (Max Plank Institute for Gravitational Physics - AEI Hannover - 10 m Prototype)

Presenter: CARLASSARA, Matteo (Max Plank Institute for Gravitational Physics - AEI Hannover - 10 m Prototype)

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