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A fibre-based interferometric displacement sensor for the Einstein Telescope

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New scientific innovations are currently being studied for improving the seismic isolation of the Einstein Telescope over second generation gravitational wave detectors. Especially in the area of displacement and inertial sensors, a lot of progress has been made within the last decades. Here, we will present our concept of a compact fiber-based displacement sensor, consisting of a heterodyne interferometer connected to a miniaturized sensor head by an optical fibre. As the sensor head will consist of a Meta-structure, which acts like a lens and a polarising beam splitter at the same time, the displacement sensor is desirable compact and hence easy to implement into an optical setup while targeting a sensitivity below 1 pm/$\sqrt{Hz}$ between 1 Hz and 200 Hz. Besides the concept of the sensor, we will discuss the construction of the Meta-structure optical head and the measurements we performed to estimate the noise floor of our interferometric readout. In our interferometer, we assign the reference and the probe signal with a different frequency and a different polarisation. In order to minimize the noise that is not common for both signals, we send both through the same fibre and separate them only inside the optical head. As the polarisation states of the signals are orthogonal, they might not experience the same fibre noise. Therefore, we will study the noise induced by the fibre as well as the noise induced by our optical readout scheme itself. In order to do this, we built a mimic of our proposed sensor head and performed the associated measurements. We will show the results we achieved so far, reaching a sensitivity of 2 pm/$\sqrt{Hz}$ between 10 Hz and 100 Hz. Finally, we give an outlook on the noise sources we are going to investigate in the future to further reduce the noise power of our displacement sensor.

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