Newtonian noise cancellation with Deep Learning

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Alessio Cirone,[1,2] Andrea Chincarini,[1] Stefania Farinon,[1] Tomasz Bulik,[3] and Jan Harms[4,5]

[1]*INFN, Sezione di Genova, I-16146 Genova, Italy*

[2]*Università degli Studi di Genova, I-16146 Genova, Italy*

[3]*Astronomical Observatory Warsaw University, 00-478 Warsaw, Poland*

[4]*Gran Sasso Science Institute (GSSI), I-67100 L'Aquila, Italy*

[5]*INFN, Laboratori Nazionali del Gran Sasso, I-67100 Assergi, Italy*

ABSTRACT

We propose a method to subtract the Newtonian Noise (NN) from Gravitational-Waves detectors which could - in principle - work in real-time. The problem consists in predicting the NN-induced displacement of the test masses with limited time-frame data from an array of heterogeneous and sub-optimally positioned seismic sensors. We seek to overcome the strong dependency on the sensors position which affects the Wiener-filter based subtraction approach, here considered as the current gold standard.

We trained a deep neural network (DNN) on 39 band-filtered seismic sensors deployed at the VIRGO site. As NN proxy we used an additional single seismic sensor close to one test mass. The DNN architecture was optimized on training data with a genetic algorithm in order to find a balance of robustness, speed and performance. A set of finite-element analyses are currently under way to test DNN performance versus sensors number and positioning, soil parameters and impact of the building structures. Simulations are also used to verify the equivalence of the single seismic sensor as proxy of the NN displacement on the test masses.

Given the fast computational speed of DNN we believe that this approach has the potential for a real-time mitigation. Current limitation of this study is the availability of the true NN signal, which should however be detectable once NN becomes a dominant source in the detector sensitivity curve.