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PL3.2 - Keynote

Dynamic Gravity

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Abstract:

With many recent advances in multi-messenger astronomy, fully controlled transmitter receiver laboratory experiments on dynamic gravitational fields (DGFs) have become more important. This implies measuring their phase and amplitude behaviour and assessing any non-gravitational crosstalk. Here we will present two new experiments in this context. While there is consensus that static (i.e. mHz) gravitational fields cannot be attenuated, to the authors' knowledge, shielding effects for DGFs have not been experimentally investigated. Theoretically, the absorption cross-section is expected to be proportional to frequency squared. Usually, dynamic experiments consist of a periodically moving mass distribution (here two rotating tungsten bars). The detector system consists of a high Q (104), 42 Hz resonant titanium bending beam. Its gravitationally induced motion is analyzed using three laser Doppler vibrometers and multichannel lock-in amplifiers. Of paramount importance is a highly temperature stable environment and the vibration isolation of the detector from ambient noise and crosstalk from the transmitter. Here we present progress on several fronts: High precision gravitational interaction modeling, quantitative crosstalk assessment and transmitter characterization using neutron imaging. The laser interferometers are calibrated at the measurement frequency specifically for the extremely small displacements in the pm range. This results in an estimated measurement uncertainty of around 0.1% for Big G. In addition, we will present experimental results on shielding of DGFs using different metal shields with dimensions of about 1.4 × 0.3 × 0.1 m and mass of up to ~500 kg placed in between transmitter and detector. The signals for the two shield positions (with/without shield) are best analyzed by fitting a single degree of freedom response function in a ceteris paribus mode. At a frequency of more than four orders of magnitude higher than previous quasistatic shielding investigations, the relative change of amplitude and phase of the response signal is very small for both a 9 cm thick brass shield and a 10 cm thick lead shield.

[1] Brack, T., Zybach, B., Balabdaoui, F., Kaufmann, S., Palmegiano, F., Tomasina, J.-C.,Dual, J. (2022). Dynamic measurement of gravitational coupling between resonating beams in the hertz regime. Nature Physics, 18(8), 952. doi: 10.1038/s41567-022-01642-8
[2] Brack, T., Fankhauser, J., Zybach, B., Kaufmann, S., Palmegiano, F., Tomasina, J.-C.,Dual, J. (2023). Dynamic gravitational excitation of structural resonances in the hertz regime using two rotating bars. Communications Physics, 6(1), 270. doi: 10.1038/s42005-023-01389-5

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