Detecting gravitational waves using electromagnetic cylindrical cavity

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With the detection and measurement of the gravitational waves with the LIGO detector, a new kind of astronomy is born. We can use gravitational waves to get some information about some objects like black holes. But the LIGO detector or other detectors using light interferometry are able to detect some range of frequencies that corresponds, for example, to binary black hole or neutron star mergers. It could be interesting to measure some other ranges of frequencies to explore some different objects in the universe, which leads to the conception of new detectors of astrophysics gravitational waves.

In our case, we will use electromagnetic fields to detect gravitational waves emitted from the universe. The idea to detect gravitational waves with electromagnetic fields is a consequence of the Einstein's Equivalence Principle. All types of energy, associated to any of the four fundamental forces, undergo an external gravitational field, and vice versa. So we can use a gravitational wave produced by an astrophysical source to create some electromagnetic field. This idea was first imagined by Gertsenshtein [1] in the 1960's, then Grishchuk [2] made some analytical work considering some electromagnetic cavities.

Let us consider a gravitational wave traveling in a cylindrical cavity with an external longitudinal magnetic field, a cavity like the ADMx experiment. It produces a variation of volume in the area and consequently of the magnetic flux, this variation enhances electromagnetic waves. We first compute analytical work to obtain a wave equation for the EM field sourced by the interaction between the gravitational waves and the magnetic field, the second step was to express the source terms, to produce some numerical simulations to identify TM and TE cavity modes excited in different configurations. We finally discussed some detectability considerations, in terms of technological feasibility and a brief review of different astrophysical sources that could be strong candidates for the interest of the detector. The study of the detector will speak about its directionality, its sensibility with frequency and amplitude, its complementarity with laser interferometers regarding the sources.

Further studies could lead to an gravitational waves emission/detection experiment, which could be a nice candidate for testing the equivalence principle.

References

[1] Gertsenshtein, M.E. (1961) *Wave Resonance of Light and Gravitational Waves.* Journal of Experimental and Theoretical Physics, 41, 113-114, English Translation in Soviet Physics JETP, 14, 84-85 (1962).

[2] Grishchuk, L. P. (1977). *Gravitational waves in the cosmos and the laboratory.* Physics-Uspekhi, 20(4), 319-334.