Significance of the Detection of Gravitational Waves published by the LIGO Team in February 2016

Jochem Hauser, 18 February 2016*

In the newspapers the detection of gravitational waves by the LIGO team has been heralded as a new era in physics. However, it seems that these statements are an exaggeration. There is too much incorrect information, not to say hype. For instance, read the unscientific language used in the Scientific American about this effect.

There was already a Nobel prize for gravity waves in 1993 (Hulse & Taylor). Hence, they are not a surprise at all.

For our own book : *Introduction to Physics, Astrophysics, and Cosmology of Gravity-Like Fields*, it is good news that these waves were found, because we already stated: Einstein's *GR* is the only answer to gravitational fields in the cosmological realm, that is, all competing theories are ruled out. But this does not mean that extensions to *GR* are not possible.

According to our own *EHT* theory (better: physical model): any gravitational theory predicting gravity must be fully compatible with Einstein's General Relativity theory, except for predictions of what happens inside a black hole. Even for very small accelerations it seems unlikely that *GR* will fail. A discussion is given in our book on pages 362-367, where the most recent important experimental results from M. Kramer and N. Wex, MPI Bonn, Germany are also presented– that leave practically **no room** for alternative theories.

Now, there is an interesting point. Gravitational plane waves (reducing the degrees of freedom in the metric tensor) are predicted by the linearized Einstein equations that are similar to the Maxwell equations (also discussed in our book). However, *GR* is a nonlinear theory. If you want to confirm Einstein's non-approximated *GR*, you must first ascertain that the nonlinear field equations of Einstein allow for waves also. As far as we understand, they do. This is not trivial since there is, in principle, graviton-graviton interaction (here the duality between the metric field $h_{\mu\nu}$ and the particle picture, i.e., the graviton, is used, that is, we introduce a concept of quantum mechanics into *GR*) that, for instance, does not exist for photons. Because of the metric field as a second rank tensor, it can be shown that gravitons have spin 2 (difficult to proof since this must hold in the relativistic case, too, see E. Wigner 1939), while the photon has spin 1.

The crucial point is: can the gravitational signals detected be interpreted with Einstein's linearized equations or do you need the full nonlinear ones? It seems from the (supposed mechanism!) black hole masses involved, about 30 and 40 solar masses, that the linear theory might match the measured data (this needs still to be confirmed). Relativistic (nonlinear) effects become spectacular, when $GM/rc^2 = 1$. This means if the two black holes that are supposed to have generated the gravitational waves have a diameter similar to the Sun, the magnitude of the relativistic gravitational effects becomes about $6-8\times10^{-5}$ on the surface of the black hole, and the linear theory should be correct. On the other hand, astronomers claim to have measured the radius of a black hole in Sept 2012 and are telling us it is about $5.5\times r_S$, where r_S is the Scharzschild radius (light cannot escape from the black hole if it is closer than r_S). For the Sun $r_S = 1.5$ km. It is believed that black holes have an r_S about 100,000 times smaller than the Sun. If this were the case, then it would be a test of the nonlinear field equations, provided of course, that the underlying assumption of two merging black is correct. However, I do not know the radius of the black holes observed in the LIGO experiment.

So it is not (completely) clear to me whether or not *GR* has been confirmed !

Any gravitational theory that gives the same linearized equations as Einstein's theory would have passed the test, too.

In conclusion, the experiments seem to have found gravitational waves, but this effect might be explained by a linearized gravitational theory. Moreover, if Einstein's nonlinear equations turn out to be necessary to explain these results (more probable), we are talking about the science of November 1915! A revolution of physics owing to the detection of gravitational waves is not in sight.

The much more important question remains unanswered, as pursued by Einstein from 1915 till the end of his research activity: is there an **interaction between gravity and electromagnetism**?

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In our book we propose a model that should lead to a conversion from electromagnetic to gravity-like fields caused by the phenomenon of symmetry breaking (unknown to Einstein), and *GR* consequently needs to be extended, that is, additional gravitational particles should exist. This should allow us to generate gravity-like fields similar to the generation of magnetic fields. This effect, not the extremely weak gravitational waves, could open up a totally **new field** of technology.

From an experimental point of view, however, the Ligo measurements are extremely sophisticated. They claim to be able to see distance changes in the range of 10^{-19} m (this is much less than the radius of a proton !).

So congratulations to the LIGO experimenters (earthbound experiment), not LISA!

Chapeau !!

The effect of a gravitational wave on the spacetime structure can be described as follows: a polarized gravitational wave traveling in one direction only acting on a circle of particles is leading to an oscillatory motion, compressing and elongating the diameter of the circle, forming an elliptic shape, but also does rotate the axis of the ellipse. Hence, a signal in both arms of the laser interferometer should be detected. In the linear theory one can calculate the radiation (energy flux) coming from such a binary star system. I have not seen comparisons yet.

The energy radiated (by the narrowing of the joint orbit) from the *binary pulsar PSR 1913+16* has been calculated from linear theory and exactly matches the observations.

In March the space antenna LISA Pathfinder from ESA will begin operating. We may expect to see a confirmation of gravitational waves by eLISA, planned for 2028 – if we are still alive.