Heidelberg, Febr 28, 2007

Some comments to the paper of Tajmar et al. (STAIF 2007)

The authors report experiments to correlate what they call gravito-magnetic fields with the output of acceleration detectors positioned around rotating superconductors.

It is not clear that a time-varying gravito-magnetic field, if it exists at all, would induce a gravito-electric field. While it is tempting to fabricate analogies to Maxwell's equations, such a correlation requires introduction of another exchange Boson to the Standard Model that would be responsible for a presently unknown link between electromagnetism and gravitation (variations of electromagnetic field strength then would be reflected by inertia of a probe). Presently the ratio of the strengths of gravitation to electromagnetism is extremely small (for a proton and an electron, the gravitational force is about 10^{-40} weaker; this ratio of course depends on the mass of the partners). The Standard Model assumes unification of these two fundamental interactions (and of their weak and strong nuclear companions) only in a very early phase of the universe. The hypothetic new exchange Boson, if it exists at all, perhaps will not be observable even if highest energies would be available in future particle accelerators. Why should it, or its impacts , be observable in LT experiments?

The Einstein-Maxwell equations are part of general relativity theory (first order approximation in flat spacetime). It is not just an analogy – and it has been measured at least for the Earth and also on an astronomical scale (gravitomagnetic field from the Earth, etc.). Why a superconductor makes a difference – although I have some theoretical models, if I'm perfectly honest – I don't know!

Likewise, it is not clear that a gravitational field could be induced by an analogue to Lenz's law. If it existed, a comet penetrating into the Solar system would induce an anti-gravitational force the magnitude of which increases with relative velocity and with reducing distance to the Sun. Impact of the comet onto the Sun would be impossible. Or consider the start phase of a missile: If a gravitation counterpart of Lenz's induction law existed, it would induce an attractive force in addition to the natural gravitational attraction, which certainly would have been detected meanwhile.

It does according to GRT – but it is classically too small to be detected.

It is also speculative to assume the magnitude of the gravito-magnetic field would decrease like in electromagnetic fields over distance. That no acceleration was observed by the reference detectors does not speak in favour of the existence of a field decaying with distance from the sample. A much more simple explanation is that no exotic field was present at all. Zero signals from the upper accelerometers could be the consequence of elastic deformations of the three shafts (Fig. 2a), see below.

Again, the gravitomagnetic field of the Earth has been measured – and the field position at the position of the satellite corresponded to the usual decaying over distance to better than 10-20%. If the effect is a mechanical artefact, why should the force point in the opposite direction? The position of the reference sensors is not close to the angle point as well, so any elastic deformation should be visible in the reference position with at least 66% of the in-ring value.

Another critical issue of the reported experiments with the laser gyros is thermal fluctuation in the experimental setup. The authors kept the rotating superconductor rings below LHe level, which means conversion of rotational energy to thermal energy that is delivered to the fluid causing its evaporation. Thermal fluctuations lead to corresponding thermal expansion/contraction of the applied construction materials. High precision experiments reported in the literature to measure Earth's rotation by the Sagnac effect can reasonably be performed only if materials with thermal expansion coefficients as small as $0.5*10^{-8}$ 1/K are applied. To obtain a resolution of 10^{-9} in such experiments, lock-in of the two laser beams running in opposite direction through the gyro ring has to be avoided, which requires large gyro ring dimensions, in the order of 2 x 2 m^2 of its area, and a stability of below 1 nm of the ring area and its perimeter (a size of 1 m^2 would be too small to resolve changes in Earth rotation; reports describing such experiments say the main problem with small rings is the coupling between both laser beams due to backscatter, which is strongly reduced with increasing size; backscatter makes the instrument extremely sensitive to perimeter changes). The whole apparatus usually is installed several meters below ground, with extensive thermal shielding and with heavy concrete base plates. Realisation of the present experiment, however, is very far from this. It is not reported how the authors kept LHe on a constant filling level and how they controlled thermal stability of the detectors and their environment.

The fibre optic gyros used do not use the Sagnac effect with its lock-in problems but relies on the Doppler frequency shift proportional to the velocity. There is only one laser beam in a coil of several kilometres length wound up in the gyro box. The gyro's precision is $2x10^{-5}$ rad/Sqrt(Hz) which is much worse than the precision gyroscopes used to measure the Earth's rotation (they would not fit inside the apparatus with their size). The paper describes the thermal management of the sensors: The sensors are in an evacuated chamber with MLI isolation – with heaters and temperature monitors on each sensor level.

Further, it is not clear that the Faraday cage made of stainless steel would effectively screen the detectors from (real) electrical fields arising from laboratory equipment. The specific electrical resistance of stainless steel at RT it is almost two orders of magnitude above the value of Cu.

Agreed. As mainly all measurements are done with a pressurized air motor – from where should the strong EM fields come? We carefully monitor the magnetic environment inside the measurement chamber.

And it is not clear why the effect, it if exists, should not be observed with HTSC. The authors exposed YBaCuO to temperatures near T_c and below 10 K. They argue the density of Cooper pairs is much smaller in HTSC in comparison to Nb. However, measurements of the Knight shift clearly demonstrate that with decreasing temperature coupling of electrons to zero spin Cooper pairs increases strongly. This means the claimed effect, if coupled to the mass of Cooper pairs, should be visible also in HTSC, at very low temperatures.

I don't know.

Concerning spin coupling, an experiment that claims precise measurement technique of angular velocities and accelerations, to detect the fingerprints of an unknown field that in turn relies on the masses of Cooper pairs, should check also possible contributions of the spins of the Cooper pairs to the reported results. As a Bose condensate, there is a single wave function only and, accordingly, a single total spin; why should total spin be neglected against total mass of the Cooper pairs?

Classical low-temperature superconductors are s-wave superconductors – with Spin 0. No spin contributions take place. That might be different for HTSC – but this is even theoretically not clear.

The reported correlation between accelerometer signals with applied angular acceleration to the superconductor samples, and in particular, the opposite signs of both curves (Figs. 6 to 8 of the paper), could speak in favour of the existence of a presently unknown field. However, if compared to the huge efforts taken in the above mentioned measurements of variations of the Earth's rotation or of short-term polar motions, the present experiment, even when using 1.5 t sand to damp vibrations of the cryostat from the rotating ring, cannot exclude mechanical disturbances delivered from "natural" sources to the accelerometers: It seems the three solid shafts, because of their elasticity, are the weak point. An analysis of the mechanical behaviour of the shafts under continuous or periodic load is missing.

Taking into account elastic properties of the shafts, the opposite sign of the curves, and even the zero result obtained in the "curl configuration", probably could be explained by conservation of angular momentum. Differences observed between results from YBCO and Nb samples (Fig. 8a,b) possibly would correlate with different sample mass or different rotational speeds of the rings.

Agreed – and we did some mechanical analysis already. But I strongly believe that the reference position sensors are the best indication that it is not a mechanical artefact. Also, why should conservation of angular momentum only take place below 9 Kelvin?

The authors should improve their experiment according to standards regularly observed in geodesics. Simple conservation of angular momentum would also make their speculations superfluous concerning a possible interaction of gravito-elecromagnetic fields with space-time or dark energy.

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There is clearly more work to be done – and I'm planning a new publication before summer which will make things hopefully more clear.