

Full Paper

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PACS: 03.; 11.; 77.; 04.80 Cc

Received : June 25, 2014

Accepted : August 05, 2014

Published : August 15, 2014

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Reality of gravity-like fields? Part II: Analysis of gravitomagnetic experiments

Abstract

In this paper (which is a follow up of the accompanying paper by W. Dröscher) an in depth analysis of three recent gravitomagnetic experiments is given. These experiments are unique, since there is a possibility that extreme gravitomagnetic fields outside general relativity might have been generated. The experiments were carried out in entirely different environments and are not related in any aspect, except that the effects reported are dependent on cryogenic temperatures. Furthermore, completely different measurement techniques were employed. The set of three experiments comprises the two laboratory experiments by Tajmar et al., Graham et al., and the NASA-Stanford University Gravity Probe-B space experiment. The physical phenomena observed could indicate the existence of novel physics outside both general relativity and the standard model of particle physics, and also would have major implications on the standard model of cosmology. Qualitative as well as quantitative comparisons between a physical model (Extended Heim Theory (*EHT*), which predicts the existence of extreme gravitomagnetic fields under cryogenic temperature conditions) and experimental results are presented. Several, so far unexplained, observations will be addressed. For instance, a physical explanation for the signal decay in the different experimental setups in the experiments by Tajmar et al. as well as the so called parity violation, seen in both experiments by Tajmar and Graham, will be given. Moreover, the difference in signal strengths between rings and disks, as reported by Tajmar etc., will be discussed. The tangential acceleration and deceleration of the four Nb coated quartz spheres and their mutual interactions in the GP-B experiment are explained through the existence of extreme gravitomagnetic fields. Finally, in order to clarify the currently non-conclusive experimental situation, a gravitational (Gedanken) Aharonov-Bohm experiment is portrayed that utilizes the interference of matter waves to measure the impact of such fields, being independent on the magnitude of gyroscope data, and, if feasible, would provide a *yes-no* decision on the existence of extreme gravitomagnetic fields.

Keywords

Analysis of extreme gravitomagnetic fields and gravity-like fields in the laboratory; Gravitomagnetic field experiments by Tajmar et al. and Graham et al.; Analysis of the Gravity Probe-B experiment; Gravitomagnetic Aharonov-Bohm effect; Gravitational engineering.

ANALYSIS OF EXPERIMENTS BY TAJMAR, GRAHAM, AND GP-B

In the accompanying paper by W. Dröscher^[1] three experiments were presented that might have gen-

erated extreme gravitomagnetic and/or gravity-like fields (acceleration fields) in the laboratory (Tajmar et al., Graham et al.) or in space (Gravity Probe-B). The enormous magnitude of these gravitomagnetic fields (compared to *GR*), if confirmed, would mean

that a novel gravitational phenomenon outside *GR* would have been detected. An extension of *GR* would have far reaching consequences both in physics and technology. Thus, the following presents an analysis of the measured data underlying these three experiments, possibly indicating the novel fundamental physics. This paper should be considered a first attempt to provide a consistent physical basis for explaining the surprising and also seemingly contradicting experimental phenomena reported. An in-depth analysis is given in our forthcoming primer entitled *Introduction to Physics and Astrophysics of Gravity-Like Fields*^[2] that will deal in detail with the physics of gravity-like fields as well as their impact on novel technology in the form of gravitational engineering. Some of the theoretical aspects of the novel physics, termed *EHT*, of these extreme gravitomagnetic fields are dealt with in the companion paper by Dröscher^[1].

First, however, it is necessary to analyze the quality of the experimental data, discussing the *pros and cons* of the experimental reality of extreme gravitomagnetic fields. Two different hypotheses are investigated in order to explain the physical basis of the unusual phenomena that might have been observed in these experiments.

In scenario one, the assumption is made that experimental artifacts in form of acoustical vibrations (Tajmar et al. experiments^[3-7,22]), a null effect (Graham et al. experiments^[8]), and a classical electrostatic phenomenon (Gravity Probe-B experiment^[9-11], whose final results were released in 2011 after six years of data analysis) are responsible for the unexpected measured data.

The second scenario assumes the existence of extreme gravitomagnetic fields, which, however, must have been generated outside general relativity (*GR*), produced at cryogenic temperatures by a novel physical interaction (according to *EHT*) of electromagnetism and gravity, caused by (delayed) symmetry breaking. This physical mechanism is subsequently employed to show that in all three (highly different) experiments these fields would necessarily exist. Moreover, it is the four rotating Nb coated quartz spheres in the GP-B experiment that are deemed responsible for the production of the extreme gravitomagnetic fields. In this case, an interaction among the four spheres was observed and

substantial changes of the angular momentum of the individual spheres were measured. Hence, it is argued that there should be room for the hypothesis of the presence of extreme gravitomagnetic fields, which might co-exist together with the electrostatic patch effect assumed to be responsible for the observed large gyro misalignment by the Stanford team.

The physical properties of the extreme gravitomagnetic fields are subsequently used to explain all observed (unusual) phenomena in the three experiments and to compare theoretical and measured results. Finally, the evidence of the two different hypotheses is weighted, and it is argued that the existence of extreme gravitomagnetic fields possesses a *higher* degree of probability in fully describing all unusual physical phenomena seen in the three experiments.

Nevertheless, the experimental situation derived from these three experiments is *not* conclusive (there is no extreme gravitomagnetic field smoking gun), and therefore in Sec. II an entirely new set of (Gedanken) experiments is suggested, based on the interference of matter waves, i.e., a so called *gravitomagnetic Aharonov-Bohm* effect (if feasible in practice) should be measurable, that, if observed, in general unmistakably (because of interference) would resolve the issue of the existence of extreme gravitomagnetic fields.

The analysis of the gravity experiments by Tajmar et al. (performed over a period of eight years) has become controversial. Recently, M. Tajmar re-interpreted his results in^[7] and also in a presentation given at the Institute of Aerospace Engineering, TU Dresden, July 2012, though he did *neither recant nor retract* his results^[23]. Tajmar has re-interpreted his earlier observed signals as null results, i.e., as artifacts caused by *acoustic vibrations*, and *not* by the presence of extreme gravitomagnetic fields. Tajmar, however, does not exclude alternative interpretations, but regards the acoustic vibration hypothesis, at least at present, as the most probable cause for the recorded strong signals. The physical arguments on which his interpretation is based, are given in the next section (Sec. I.A).

The analysis of the experiments by Graham et al. is also controversial, since the experimentalists classified their measurements as null results, a view

not shared by the author. Furthermore, in GP-B, an *electrostatic patch effect* (see Sec. I.C) was claimed to be responsible for the observed gyroscope misalignments. All of these views are challenged by the author, who claims that neither the acoustic vibration hypothesis, nor the null results of Graham, nor the patch effect in GP-B are fully conclusive to answer the remaining anomalous observational facts. The theoretical analysis for the three gravitomagnetic experiments is presented in Secs. I.B and I.C. However, even if the arguments *in favor* of the existence of extreme gravitomagnetic fields turn out to be more convincing, at least to the author, there is not yet a decisive argument or proof for this kind of novel physics. In order to present the smoking gun (to use the phrasing of the well known theoretical physicist M. Kaku, for instance, see his Youtube videos on the existence of UFOs), novel experiments have to be performed as will be outlined in Sec. II by presenting a Gedanken experiment^[24].

Analysis according to the arguments of Tajmar

In this section the arguments are presented (as ensuing from the e-mail discussion between M. Tajmar and the author) that ultimately lead M. Tajmar to re-interpret his earlier results.

In the following, we list the conclusions and recommendations reached by M. Tajmar^[25]:

1. Recent results obtained with configurations termed Setup D and E (as published in November 2011) are one or two orders of magnitude lower than previous results from Setup A and B: upper experimental limit of coupling factor (for a definition see Eq. (1) in the paper by W. Dröscher^[1]) $C_R = 3 \times 10^{-10}$ for superfluid He, and 4×10^{-11} for liquid He (superconductor).
2. Previous larger effects inside the cryostat are *not* gravitomagnetic in nature and *most likely* facility artifacts (vibration, resonance), to be *confirmed* by future measurements.
3. Rotating superconductors or superfluids do *not* produce large frame-dragging fields.
4. Recommendation: replication attempts should focus on Setup A and B, maybe the *cold environment around the sensors* makes a difference.

The last topic (recommendation) will be discussed further in the the next two sections.

The main difference in the two sets of experiments is the location of the gyroscope. In Setup A (see Figure

1) the gyroscope is inside the cryostat, while in Setup E (see Figure 3) it is positioned outside the cryostat. Apart from that, the two experiments are the same and thus, according to Tajmar, should produce the same extreme gravitomagnetic field. Acoustic vibrations might have been generated by the combination of rotating sample holder and evaporating He (siren effect as discussed in the next section). Since in Setup E the gyroscope is outside the cryostat, these acoustic vibrations cannot influence the gyroscope, i.e., producing artifacts that are incorrectly interpreted as extreme gravitomagnetic fields. Consequently, the signal strength is drastically reduced, down to the noise level of the gyroscope. This, in a nutshell, is the argumentation by Tajmar for not having measured any extreme gravitomagnetic fields in any of his experiments. This conclusion is not accepted as fact, but at present, for Tajmar seems to be the most plausible explanation. Alternative interpretations are not excluded, provided a consistent physical explanation can be found.

Analysis of Tajmar and Graham experiments by EHT

In the preceding section, the analysis by M. Tajmar for the re-interpretation of his experiments was presented. Now a different view is given, based on the *existence* of extreme gravitomagnetic fields.

The major reason for interpreting the strong signals measured in Setup A (or B) as *acoustic vibrations* and *not* as extreme gravitomagnetic fields was that Tajmar could not find any physical explanation for the drastic reduction in signal strength when, for instance, Setup E was utilized. Tajmar only hinted (see previous section) at the *cold environment* present in Setup A and B that might have played a role.

According to *EHT*, it is *not* the cold environment around the sensors that impacts the signal strength in Setup A or E, but the *prevailing factor* seems to be the temperature field of the *entire* spatial environment through which the (eventually) closed field lines of the extreme gravitomagnetic field have to propagate, before they are recorded by the gyroscope. It is postulated that a temperature field changes both the magnitude and direction of the \mathbf{B}_{gp} field, as will be discussed below. High temperatures (with reference to the temperature of liquid He) are supposed to generate a highly diffusive

field, i.e., causing B_{gp} field lines to curve (producing strong field line curvature), and thus less field lines are reaching the sensors. Consequently, signal magnitude is substantially reduced.

Hence, in this section and the next one, physical arguments are presented to corroborate this interpretation.

First, a physical explanation, based on the generation of extreme gravitomagnetic fields will be given that consistently explains the signal reduction from Setup A to E.

Second, if extreme gravitomagnetic fields are indeed present, they should not only be capable of explaining the problem of signal reduction, but also need to explain a more comprehensive catalog of phenomena (as listed below) that were also observed in the experiments by Tajmar et al.

Third, there are the two additional experiments by Graham et al. and GP-B, whose results also need to be accounted for by the concept of extreme gravitomagnetic fields.

As a caveat, it should be noted that even if the physical model of *EHT* can deliver consistent explanations for the phenomena observed in the three experiments, would this mean that the existence of extreme gravitomagnetic fields finally has been *proved*? The answer is a resounding *no!* The best case scenario presently achievable is that the arguments for the existence of extreme gravitomagnetic fields, and thus for physics beyond *GR*, appear to be *more plausible* than the hypothesis of acoustic vibrations. Physics is an experimental science and only additional experiments can resolve this issue. Therefore, in Sec. II a Gedanken experiment is presented, based on the interference of matter waves, that will give an unmistakable answer in form of a yes-no decision. Moreover, ideas for modern torsion balance experiments are considered that should provide substantially more accurate results than the earlier experiments by Tajmar et al. and Graham et al.

The physical explanation for the observed parity violation as depicted in Figure 2 is given in Sec. I.B, but was already published by the author in 2008^[19]. The theoretical ratios of the magnitude of the B_{gp} fields in clockwise (CW) and counterclockwise (CCW) directions are given by the set of integers $\{-5, -1, 1, 5\}$. The measured value is about 4.2. If no sample

is present, the field vanishes, as can be seen from the lower picture of Figure 2. The middle picture of Figure 2 shows a (strange) gyroscope output, when the ring is replaced by a disk, in that the signal strength is effectively zero for this geometry. Since the mass of the disk is higher than that of the ring, and the same material was used, one expects to see a stronger signal. Furthermore, this is also an argument for the acoustic vibrations that, according to Tajmar, might be blocked by the disk, but not by the ring.

Before the physical analysis of the three gravitomagnetic experiments can begin, a clear idea has to be obtained about the fundamentally important and really basic questions that need to be answered, in order to gain a profound understanding of the physical principles, characterizing these experiments. To this end, the following list of basic phenomena was^[26] created to address the physical explanation for the existence of extreme gravitomagnetic fields:

1. What is the physical reason for the dramatic reduction in signal magnitude when going from Setup A to Setup E in the experiments by Tajmar et al.?
2. Are acoustic vibrations (sound waves in the form of a siren effect caused by the holes in the rotating sample holder) the cause for the strong signals measured in Setup A (and B) in the experiments by Tajmar et al.?
3. What is the physical reason for the reduction in signal strength when the rotating ring and support are removed, and only the spinning axis remains in the experiments by Tajmar et al.?
4. What is the physical reason that the gravitomagnetic field strength, as observed in Setup A (and B) in the experiments by Tajmar et al., does not fall off with distance (i.e., does not exhibit classical dipole field behavior)?
5. How can the material dependence on gyroscope signal strength (about a factor 2) in the experiments by Tajmar et al. be explained?
6. How can the (slight) variation with temperature of the onset of the gyroscope signal for different materials in the experiments by Tajmar et al. be explained?
7. Why is the magnitude of signal strength in Tajmar et al. of Setup E so dramatically lower compared to the signals measured by Graham et al., although the setups are almost identical?

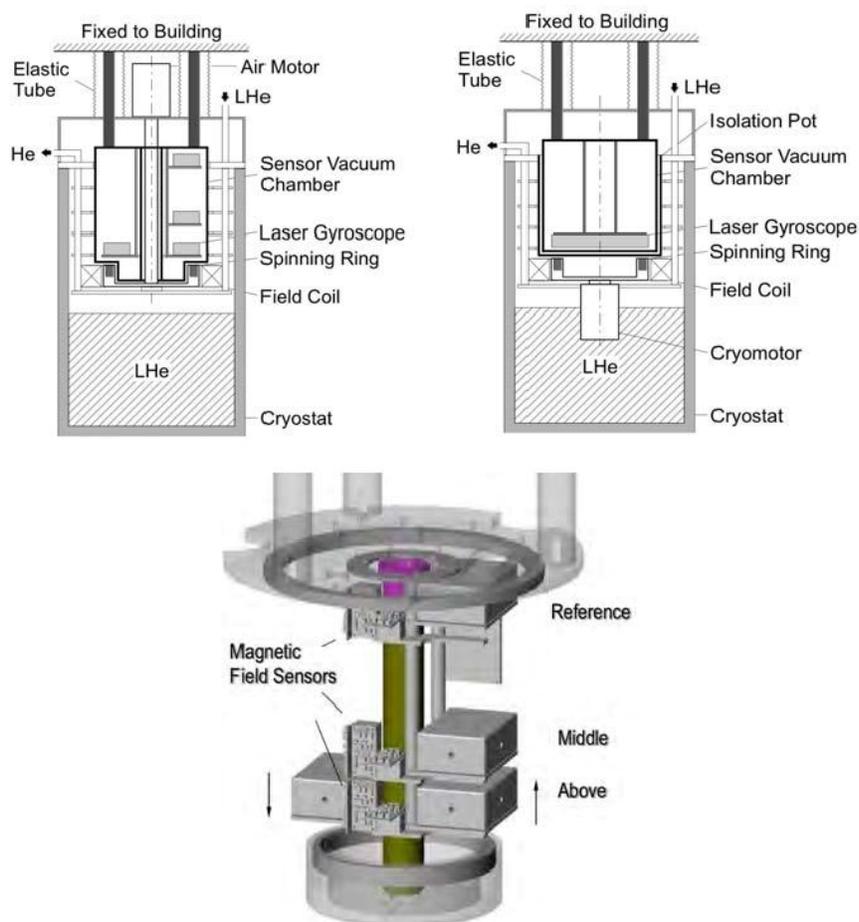


Figure 1 : Picture courtesy of Prof. M. Tajmar, TU-Dresden, Germany. The pictures show the two experimental configurations termed Setup A and B. It is important to note that in these setups the spatial region between the Nb ring (denoted by x in the upper figures) and the gyroscope(s) is at cryogenic temperature (i.e., the vacuum sensor chamber is inside the cryostat, and hence is not thermally insulated from the liquid helium), which means that the gravitomagnetic field does not traverse regions of substantial temperature gradients, as is the case in Setups C, D, and E, that are used in Tajmar’s later experiments (see Figure 3). Therefore, experimental Setup A, B are thermally not equivalent to Setup C, D, and E. In case the extreme gravitomagnetic field is influenced by temperature gradients, this might result in different signal strengths for the various setups.

8. How can the phenomenon of parity violation be explained, which was observed in all three gravitomagnetic experiments?
 9. Can an asymmetry in the bore holes of the sample holder (i.e., drilling holes with oblique) be responsible for parity violation in the experiments by Tajmar et al.?
 10. Why is the sign of parity violation reversed in the experiments by Graham et al. compared to Tajmar et al.?
 11. What is the meaning of the CW and CCW direction of rotation in the three experiments, i.e., how is the reference CS oriented (defined)?
 12. What is the physical reason for the large difference in signal strength between ring and disk samples?
 13. What is the physical reason for the observed conservation of angular momentum in the GP-B experiment for the four Nb coated quartz spheres. Does an explanation based on the proposed electrostatic patch effect exist?
 14. Fundamental question: is the physical model, based on the assumption of the *existence of extreme gravitomagnetic and/or gravity-like fields*, capable of explaining consistently all anomalous gyro effects, both qualitatively and quantitatively, as seen in the three gravitomagnetic experiments?
- Having established a comprehensive catalog of questions, a qualitative analysis is presented below, attempting to clarify the fairly complex experimental situation. To this end, the information from the two tables of the paper by W. Dröscher (TABLE 1 and 2

in^[1]) is scrutinized. After that, the physical problems raised in the list above will be addressed.

1. TABLE 1 (last row (green)): Since the gravitomagnetic effect is associated with a phase transition at low cryogenic temperatures, and liquid nitrogen has a temperature of 77 K, a zero gravitomagnetic field is to be expected, since no imaginary Cooper pairs ($e^-e_i^-$)^[27] can be formed. According to the particle classification scheme of *EHT*, electrons of imaginary mass should be produced by symmetry breaking at cryogenic temperature, forming the so called imaginary Cooper pairs, but eventually the imaginary vector potential \mathbf{A}_I resulting from the moving imaginary Cooper pairs will be converted into the extreme gravitomagnetic vector potential \mathbf{A}_{gp} (for an explanation of this mechanism see^[17]). In other words, the imaginary Cooper pairs are intermediate stages in this conversion process, i.e., they do not occur in the initial or final state of the physical system.
2. The \mathbf{B}_{gp} field is associated with Hermetry form H_9 ^[17,28], which describes non-ordinary matter (imaginary particles are classified as non-ordinary matter and are an extension of the concept of matter). The partial metric terms of this Hermetry form can be classified as symmetric or anti-symmetric.
3. As can be seen directly, Setup A, B (Figure 1) are thermally not equivalent to Setup C, D, and E (Figure 3). In case the extreme gravitomagnetic field is influenced by temperature gradients, the two sets of experiments might naturally result in *different* signal strengths. This could be the physical explanation why the magnitude of gravitomagnetic fields measured in the later experiments is decreasing with increasing thermal insulation, compare Figures 2 and 4. However, *even* in Setup E a signal can be observed, though, it does not satisfy the five sigma requirement. Though this signal is weak, i.e., weak compared to the measuring accuracy of the equipment, it must be considered a complete mystery, since it is still 16 orders of magnitude larger than predicted by *GR*.
4. Because in Setup C, D, and E the gravitomagnetic field has passed through a region with a large positive temperature gradient (see Figure 3, which

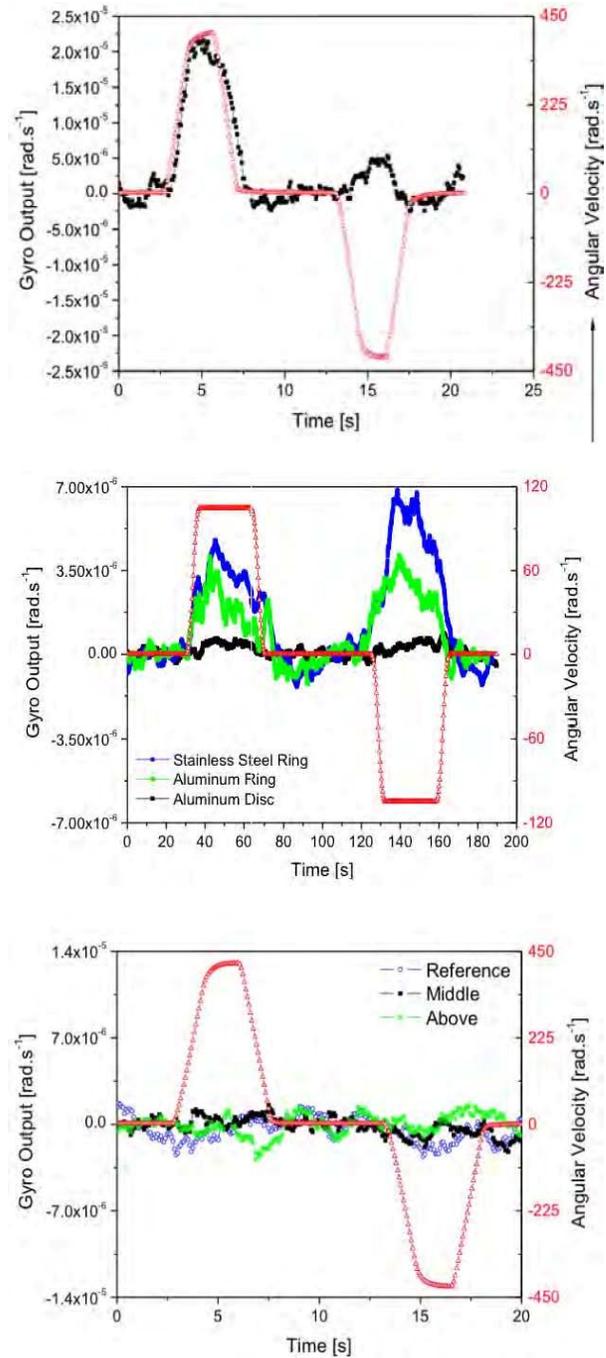


Figure 2 : Picture courtesy of Prof. M. Tajmar, TU-Dresden, Germany. The pictures show gyroscope signals (directly related to C_R) for gaseous He for Setup A, B versus angular speed ω of the Nb ring. A clearly detectable signal is seen, but there exists a strong measured asymmetry for the gravitomagnetic field \mathbf{B}_{gp} . The red curve denotes the angular velocity of the ring, the black curve gives the gyroscope output. Signal magnitude strongly depends on the sense of rotation, but also on the material utilized. In these experiments the ring was not accelerated, but rotated at fixed angular velocity.

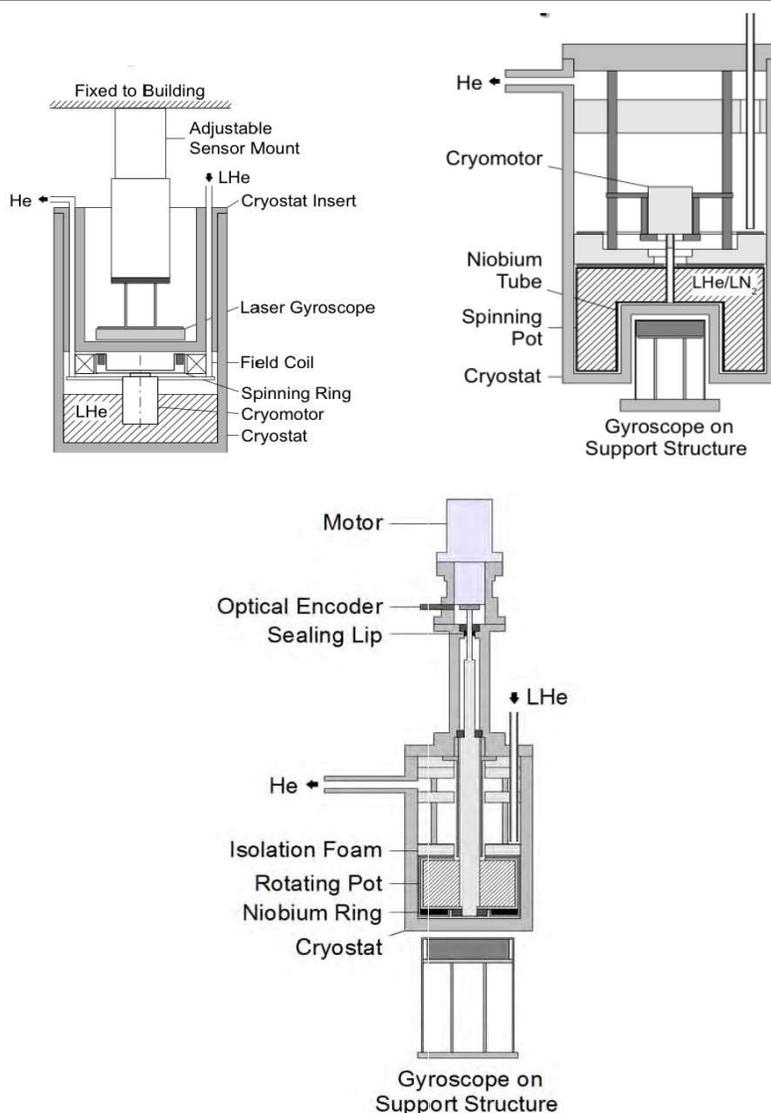


Figure 3 : Picture courtesy of Prof. M. Tajmar, TU-Dresden, Germany. The pictures show the three experimental configurations termed Setup C, D, and E. The major difference to Setup A and B is the thermal insulation between the cryostat and the sensor vacuum chamber. The gyroscope is now located outside of the cryostat and mounted on a support. When the gravitomagnetic field is measured at the location of the gyroscope, it has passed through a spatial region that is at a much higher temperature than the environment inside the cryostat. This change in configuration is the main modification when going from Setup A to E (compare with Figure 1).

is believed to have caused a substantial weakening of the gravitomagnetic field at the location of the gyroscope, and consequently producing a much smaller coupling factor compared to Setup A or B.

Remark. We claim that Tajmar would have measured an effect also in Setup E, which would still be 10^{16} times larger than the predicted frame dragging of GR, if a gyroscope could have been found with a sensitivity two orders of magnitude better than the one used. The extreme gravitomagnetic field should still be there, however, in reduced strength, but the

gyroscope is no longer sensitive enough to pick it up, i.e., to unmistakably distinguish it from the background noise level.

- First, therefore, the difficulty seems to be with the noise level of the gyroscope utilized, and *not* with the non-existing gravitomagnetic field. Tajmar initially performed measurements in the temperature range between 6 K and room temperature^[7], at which the He gas is assumed to produce a smaller gravitomagnetic field in comparison to liquid He. The temperature dependence of the coupling constant C_R was

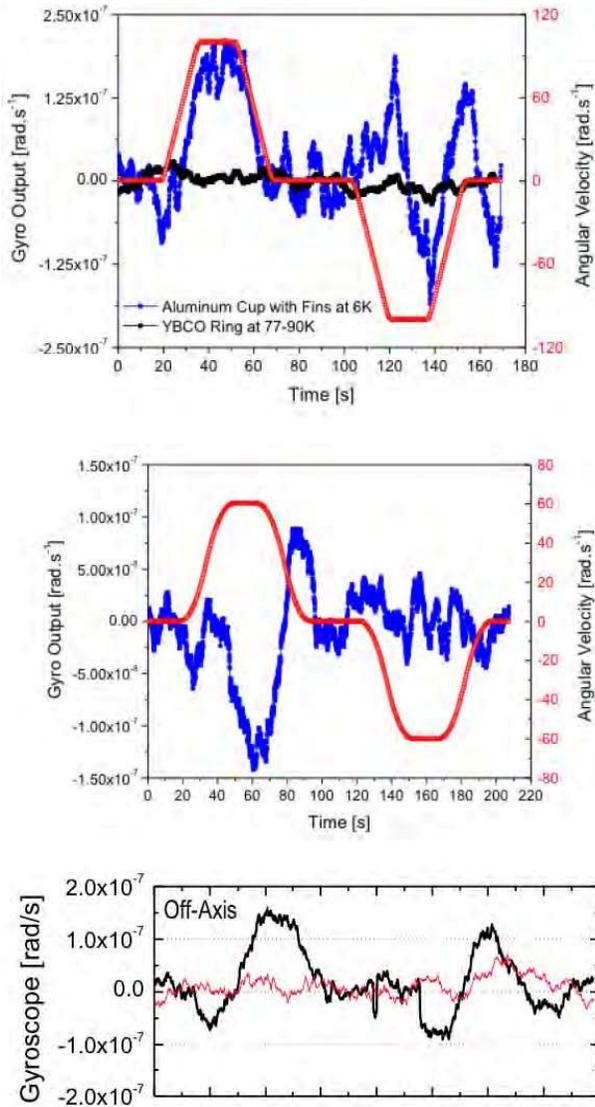


Figure 4 : Picture courtesy of Prof. M. Tajmar, TU-Dresden, Germany. The upper picture shows a reduced gyroscope output signal for Setup C, D, but, despite the reduced signal strength, the middle picture still shows the parity violation signal, i.e., the signal in the CW direction is much larger than in the CCW direction for all three experimental configurations Setup C, D, and E. The lower figure shows a gyroscope signal (black curve) even for the Setup E when compared against the curve (in red) recording the noise level of the gyroscope for the present measurement, but the signal strength (black curve) is moving within the general noise level of the gyroscope.

experimentally verified by Tajmar in^[5]. However, the sensitivity of the measurement equipment trying to measure the coupling constant of GR , C_{GR} , is many orders of magnitude too small, which is obvious when the gyroscope output is

analyzed. The noise level of the gyroscope is about 5.0×10^{-8} rad/s. Hence, frame-dragging due to GR cannot be observed. When LHe is used, a substantial shift in the gravitomagnetic field strength for the CW (clock-wise) signals can be observed. However, since the noise level is high, only a three sigma value with regard to the gaseous He is achieved; but, most important, the phenomenon of parity violation is again clearly visible in these measurements. This phenomenon was observed in *all previous experiments of Tajmar et al., and also independently reported by Graham*^[8]. Parity violation means that the magnitude of the B_{gp} field changes significantly in case the ring (disk, sphere for GP-B) is changing its direction of rotation from CW to CCW, or vice versa. It should be noted that parity violation, with regard to the change of sign of the B_{gp} field, is a qualitative physical phenomenon, which does neither depend on the sensitivity (as long as a field is seen at all) nor on the type of gyroscope, and definitely cannot be caused by acoustic vibrations, since the experiment by Graham et al. could not have generated any acoustic waves at all. In the Tajmar et al. experiments, the signal in the CW direction is significantly higher than in the CCW direction. This means that in the present measurements (Setup E), all CCW signals are mostly within or, at least, close to the gyro noise level, and thus will not be considered. It is surmised that in case a gyroscope with a much reduced noise level was used, the CCW values would be significant as well, and the measurement would be in the high sigma range, i.e., measurements would turn out to be fully conclusive. In summary, a significantly more sensitive gyroscope should be used together with a much *smaller footprint* to improve the spatial resolution of the gravitomagnetic field. However, a signal seemed to be present in all experiments. Perhaps, a modern torsion balance that can measure torques as low as $1. \times 10^{-15}$ Nm might be more suitable.

- Second, in the Setup E experiment the four measurement positions of the gyros are now *outside* the cryostat. In previous experiments, Tajmar^[5] employed three different experimental setups, termed A, B, and C for the cooling of the

cryogenic rotating Nb ring. In Setup A and B the gyroscope was surrounded by regions that were held at the temperature of LHe. In Setup C the gyroscope was already thermally insulated, and therefore at a much higher temperature level, though the exact temperature value was not determined. Measurements of the present experiment, Setup E, are consistent with the findings from Setup A, B, and C, namely that, *whenever* the gyroscope measurements were taken at locations of higher temperature, a significantly weakened B_{gp} was observed. For instance, the gravitomagnetic field strength was weakened by a factor of 40 when going from Setup A to C. In Setup E, a reduction factor of about 100 was observed compared to Setup A. Consequently, it can be concluded that the strength of the B_{gp} field in Tajmar's experiments *strongly* depends on ambient temperature T . To firmly confirm this hypothesis, the field strength should be measured both inside and outside the cryostat. For a qualitative explanation, one needs first to discern between the generation of extreme gravitomagnetic fields, and, second, their propagation in space. The generation of these fields, as discussed in^[14-16,19], is due to the cryogenic rotating Nb ring and the Al sample holder, while the LHe serves to produce a temperature that is below the critical temperature T_c , which might be somewhat higher than the temperature for superconductivity of Nb or Al, as was shown in Tajmar Figure 3 in^[5]. The range and magnitude of the B_{gp} field seem to depend on the ambient temperature field. The ambient temperature field T in conjunction with the possible gravitational polarizability of the vacuum might act in a similar way as ferromagnetic material in a solenoid, reinforcing the magnetic induction field \mathbf{B} in areas of low temperature and leading to low vacuum polarization in regions of higher temperature. Consequently, by using this analogy, the B_{gp} field will be substantially weakened in the latter region.

- In order to further elucidate the role of temperature, i.e., the impact of a cold environment on the extreme B_{gp} field, the analogy to the phenomenon of ferromagnetism will be useful. For instance, a bending magnet (or

deflecting magnet) used in high energy particle physics, comprises two coils and an iron yoke, which is a ferromagnetic substance. This means that the external magnetic field, \mathbf{H} (in the gap $\mathbf{H} = \mathbf{B}$, in the iron \mathbf{H} can be neglected), generated by the electric current through the coils, produces an enormous magnetization (magnetic moment per unit volume), \mathbf{M} , inside the iron yoke. Thus, the resulting magnetic induction \mathbf{B} is given by the sum $\mathbf{B} = \mathbf{H} + 4\pi \mathbf{M} = \mu \mathbf{H}^{[29]}$ (inside the yoke the \mathbf{H} field can be neglected compared to \mathbf{M}). Since μ can assume values of several hundred (or more), the \mathbf{B} field is increased by this large factor inside the iron yoke compared to the original external magnetic field \mathbf{H} . The \mathbf{B} field lines are concentrated inside the volume of the iron yoke, and the field strength outside the yoke will be weak. Replacing the volume of the iron yoke with the ultra-cold volume within the cryostat and the field \mathbf{B} by B_{gp} in the experiments by Tajmar et al., it is straightforward to see that a gyroscope placed outside the cryostat should measure a substantially weakened field B_{gp} , and hence, the field strengths measured by Tajmar, for instance, in Setup A and Setup E should be strongly different.

Analysis of gravity probe-B experiment

The NASA-Stanford experiment called Gravity Probe-B, launched in 2004, which was orbiting the *Earth* for more than 10 months at an altitude of about 640 km, aimed at measuring the predicted Lense-Thirring precession (inertial frame dragging by the rotation of the *Earth*, Figure 5, providing a large test mass for this extremely small effect), which amounts to some 39 mas/year. As a consequence of the frame dragging, the rate of precession of the angular momentum vector of the gyroscope, defined as $\Omega_{LT} := (L^{-1})(dL/dt)$ in radians per second, is proportional to the spin of the *Earth*, i.e., $\Omega_{LT} \sim S$. For instance, as depicted in Figure 5, suppose that the satellite is in a polar orbit (denoted as x - z plane) and the gyro axis, i.e., its angular momentum vector \mathbf{L} , is initially pointing in the y -direction. Then the frame dragging effect by the rotating *Earth* causes the satellite's orbital plane to rotate about the x -axis, producing a drift (motion) of the gyro spin axis from west \rightarrow east, as shown. Since the change of the angular momentum $d\mathbf{L}$ is perpendicular to its

original direction $L^{[30]}$, its magnitude remains invariant. In the GP-B experiment, because the gyro axis was initially pointing at the guide star IM Pegasi, a precession of the gyro axis about this direction will result.

The drift from frame dragging is small even compared to the already tiny geodesic (or geodetic) effect (spacetime curvature caused by the mass of the *Earth*, static effect) of 6.6 as/year, and thus highly difficult to measure. The geodetic precession occurs *in* the orbital plane of the satellite, while the Lense-Thirring effect causes a precession of the gyro spin axis in the direction in which the *Earth* is rotating (perpendicular to the geodesic drift, the gyroscope is assumed to be initially in free fall along the axis of rotation of the *Earth*). The situation is depicted in Figure 6. For the GP-B experiment an inertial frame was required with non-gravitational acceleration less than 10^{-13} m/s^2 (compare this value to the MOND acceleration of 10^{-10} m/s^2), i.e., providing practically a zero g (gravity) environment. That is, if such a value can be produced it must be concluded that Newton's gravitational law *is valid* down to this value, and the

idea that at accelerations in the range of 10^{-10} m/s^2 it ceases to be exact and MOND takes over, needs to be rejected. Moreover, if Newton's law ceased to be exact at the magnitude of the MOND acceleration, elliptic orbits would no longer be possible. These deviations from Newton (Einstein) should have accumulated over the lifetime of the star and (possibly) should have been observed. Furthermore, to prevent any thermal disturbances, the gyroscopes were operated at 1.8 K at the temperature of superfluid helium. The four gyroscopes had their spin axis initially pointing at a so called guide star, which was IM Pegasi (referenced by an onboard telescope, but in practice this procedure was much more complicated since a second star had to be involved). Comparing Tajmar's equipment with the GP-B gyroscopes, it is obvious that the sensitivity of his gyroscopes definitely would not have been sufficient to detect accelerations that small. One of the major challenges of the GP-B experiment was to provide an entirely drag-free (weightless) satellite in order to guarantee that Newtonian gyro drifts remained much smaller (which was not the case,

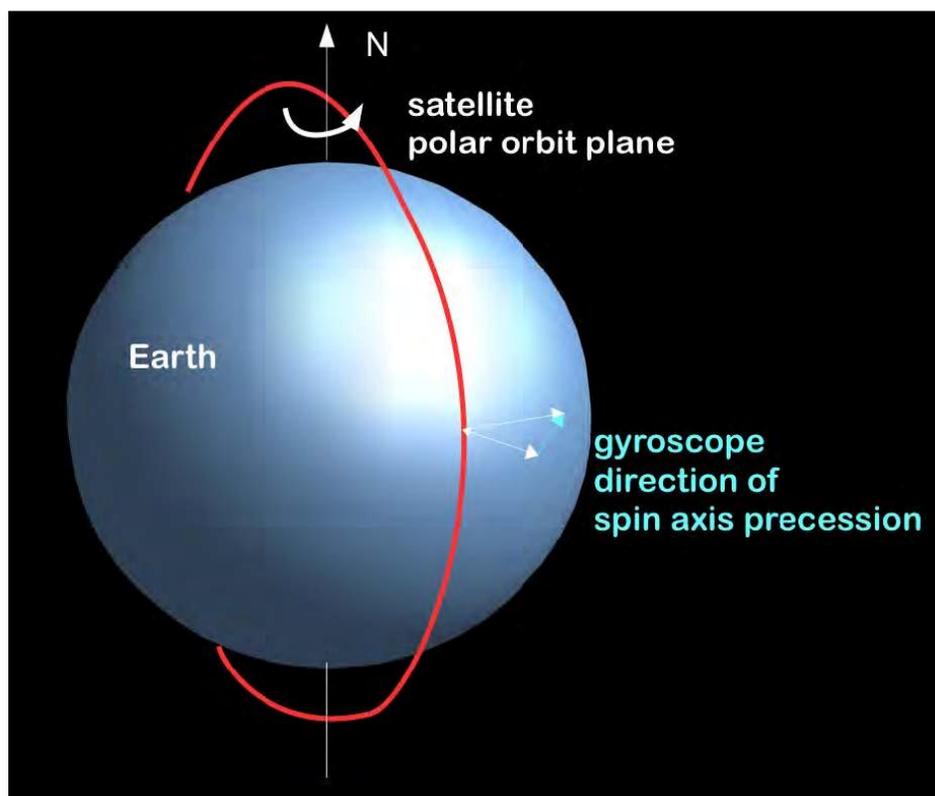


Figure 5 : The figure shows the direction of the frame dragging effect of the *Earth* on the angular momentum vector of a gyroscope in orbit. The angular momentum vector L of the gyroscope experiences a torque dL/dt with $dL \perp L$ that is, the orbital plane itself is rotating.

compare values from Figure 6 and TABLE 1) than the two Einsteinian effects (gyro drifts caused by geodesic effect and frame dragging, for values see TABLE 1).

In the following this experiment is discussed in more detail, since major unforeseen gyro drift anomalies were observed.

The existence of extreme gravitomagnetic fields cannot be explained from *GR*, which becomes clear when comparing the GP-B experiment with Tajmar's experiments. It is therefore impossible that Tajmar has observed any effect related to *GR*. His effect therefore needs to be outside *GR*, pointing to a new class of gravitational phenomena, provided, of course, that his *measurements are correct*, i.e., are not caused (they may, however, be influenced) by acoustic vibrations. This were an indication that the standard interpretation of gravity, as manifested in Einstein's 1915 *GR*, does need an extension that leads beyond the established view of gravity, simply being the result of the curvature of four-dimensional spacetime due to the presence of the energy-momentum tensor. Therefore, if experiments turn out to be correct, the two additional gravitational fields as postulated in *EHT*, represented by

gravitophotons and the quintessence particle, are at least qualitatively supported. In other words, the nature of gravity is far more complex than represented by *GR*. All predictions of *GR* are correct, but it seems that it is *GR* which is not complete instead of *QM* (quantum mechanics). Moreover, the geodetic and Lense-Thirring effects show that already in *GR* a (weak) interaction between spacetime and massive bodies exist. This could mean that the fields, possibly generated in the three experiments, being many orders of magnitude larger, should be subject to a corresponding (much stronger) interaction with the surrounding spacetime. But this is exactly what is needed for propellantless propulsion, which can only work if there is an intense *exchange of energy and momentum among space vehicle and the spacetime field*. However, in this context the concept of spacetime field needs to be explained. In the primer^[2] it will be argued that dark energy (represented by two different attractive and repulsive dark energy particles) and spacetime (conceived as a lattice) are inextricably coupled to each other. That is, cosmologically they were generated together and thus form a unity, with coupling of dark energy and spacetime (i.e., Ising

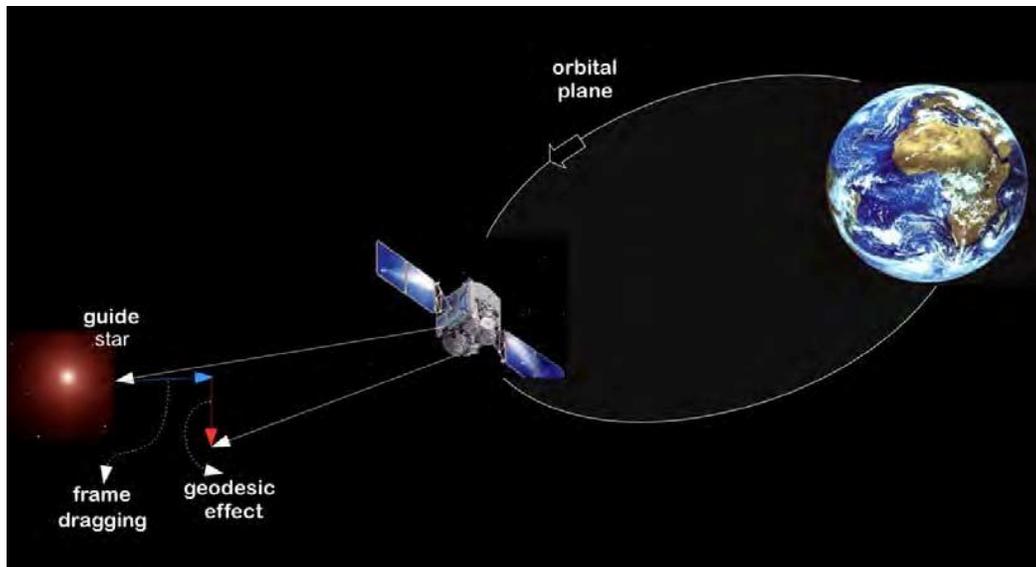


Figure 6 : In GP-B both frame dragging and geodesic effects were measured. The figure shows both the direction of the frame dragging and the geodesic effects on the angular momentum of the gyroscope of the *Earth*. Initially the satellite is assumed to be in polar orbit (rotating anticlockwise, i.e., from north \rightarrow south) as shown in Figure 5. Because of the frame dragging the angular momentum vector of the gyroscope experiences a torque *perpendicular* acting on its instantaneous orbit plane, while the geodesic effect is rotating the angular momentum (south) *in* the orbit plane, leading to an orbit that is no longer closed. The magnitude of the angular momentum remains invariant, but its direction is changing, causing a precession of the spin axis of the gyroscope. The gyro spin axis, initially pointing at a chosen guide star (fixed position), will exhibit a misalignment due to frame dragging and geodesic effect, which accumulates over time. Hence, the measuring time of about 10 months, since, in particular, the frame dragging effect is extremely small and subject to numerous sources of noise.

model of spacetime) before matter came into existence. The total energy in the *Universe* is identically zero. Dark energy is an inseparable manifestation of the creation of spacetime and is considered as some early form of matter (energy without inertia). All visible matter is assumed to be made from dark energy^[2]. Hence it should be obvious, that the term *spacetime* is used for the combination of both the atoms of space (i.e., the geometry of spacetime, ultimately spacetime must be discrete) and the associated dark energy field. In other words, spacetime and the dark energy field are *inseparable*. The atoms of space of course cannot have any mass, otherwise inflation would be impossible. However, since in *EHT* spacetime (information) and dark energy (physical energy) are determining each other, the dark energy field is generated *together* with the atoms of space and time (as described in^[2]).

In GP-B the gyroscopes are made from four spheres with a diameter of exactly 38 mm. Spheres are of the same mass and are made of quartz, thinly coated with Nb. GP-B uses two pairs of gyroscopes, namely the pairs formed by gyroscopes 1-2 and 3-4. The separation distance between the two gyroscopes within a pair is 75 mm. In each pair the first gyroscope rotates counter-clockwise, the second one clockwise.

Apart from the misalignment of the gyroscope axes that was mentioned above, it was observed that the angular frequency of the gyroscopes was changing during the experiment. At the start of the experiment, the angular frequency was about 72 Hz for each gyro. At the end of the experiment, after some 10 months, the frequency of the four gyroscopes was reported as 79.4 Hz, 61.8 Hz, 82.1 Hz, and 64.8 Hz, respectively. Obviously, the set of all four gyroscopes must satisfy the conservation of angular momentum (no interaction with the spacecraft), which is the case, since the average value of angular frequency is 72.05 Hz. This means that the angular frequency, comprising gyroscopes 1 and 3 increased, while the frequency of gyroscopes 2 and 4 decreased. According to the knowledge of the author, this effect has not been addressed by the Stanford team. This trend is even reflected in the frame dragging data as can be seen from TABLE 1. However, this probably would *not* be the case if

only the electrostatic patch effect was acting on the gyroscopes, and thus might be a clue that extreme gravitomagnetic fields have played an important role with regard to the observed gyroscope anomalies. Concerning the mechanism for the generation of gravity-like fields, an interaction between two gyroscopes operated at cryogenic temperature should take place, in the same way as it should have occurred between the Nb ring and the Al sample holder in the experiments by Tajmar et al. The gyroscopes in each pair are supposed to generate two extreme gravitomagnetic fields of opposite sign denoted by \mathbf{B}_{gp}^{CW} and \mathbf{B}_{gp}^{CCW} (the subscript *gp* is used to indicate that this field is due to the gravitophoton particle postulated by *EHT*). Let us consider the gravitomagnetic field generated by each of the (rotating) gyroscope pairs. Such a gravitomagnetic field, observed from a coordinate system, which is assumed to be fixed to the rotating surface of one of the four gyroscopes, is felt as a time dependent gravitomagnetic field produced by the other gyroscopes. This means that, according to *EHT*, an acceleration field in circumferential (tangential) direction results, i.e., a tangential gravity-like field is generated, analogous to the field reported by Tajmar et al., when the Nb ring was rotated at non-uniform angular velocity. The derivation of the magnitude of gravitomagnetic fields in the CW and CCW directions are given by^[17] (using Chap. 10 from M. Kaku^[18])

$$\mathbf{B}_{gp}^{CW} = 0.328 \alpha \alpha_{gp} \frac{6m_e}{m_p} \omega, \quad \mathbf{B}_{gp}^{CCW} = \frac{1}{5} \mathbf{B}_{gp}^{CW}. \quad (1)$$

The coupling constant in quantum electrodynamics is the well known fine structure constant, which has the value $\alpha = 1/137 \approx 7.3 \times 10^{-3}$, and $\alpha_{gp} = 1/212$ is the coupling constant for the gravitophoton interaction (i.e., the conversion strength from electromagnetism to gravity in the form of extreme gravitomagnetic fields), and $m_e/m_p = 1/1836.15$ denotes the electron-proton mass ratio, and quantity ω denotes the angular frequency of the rotating ring, disk, or sphere.

The calculation leads to a magnitude of the circumferential acceleration field in the symmetry plane of the gyroscope given by the equation

$$\mathbf{g}_{sp} = 67^3 \frac{\mathbf{v}^2}{c} \mathbf{B}_{sp}^{CW}, \quad (2)$$

where the tangential acceleration follows some kind of Lenz rule, i.e., is acting against its cause, namely against the direction of the temporal change of ω . With measuring time t (approximately 10 months) the effect should accumulate, and eventually leads to a velocity change of

$$\pm \Delta \mathbf{v} = \mathbf{g}_{sp} t = 67^3 \frac{\mathbf{v}^2}{c} \mathbf{B}_{sp}^{CW} t. \quad (3)$$

The \mathbf{B}_{sp}^{CW} field and Δv can be obtained from experimental data. A simple estimate can be done as follows. Assuming a constant acceleration g_{sp} in the circumferential direction during the 10 months period and using a radius of $R_Q = 1.9 \times 10^2$ m for the gyros (quartz spheres) as well as utilizing a change in frequency $\Delta v = 10$ Hz, the average acceleration due to the gravity-like field is given by

$$\begin{aligned} g_{sp} &= 2\pi R_Q \frac{\Delta v}{\Delta t} = 6.28 \times 1.9 \times 10^2 \\ &\times \frac{10}{305 \times 86400} \approx 4.5 \times 1.9^8 \text{ m/s}^2, \end{aligned} \quad (4)$$

which is a very small acceleration, but, applied over a period of 10 months, is leading to a velocity change of the gyroscopes of ± 1.19 m/s. From this experimental value in combination with Eq. 2 the magnitude of the corresponding \mathbf{B}_{sp}^{CW} field can be determined. From Eq. 2 one obtains

$$\mathbf{B}_{sp}^{CW} = 1/67^3 \frac{c}{v^2} \mathbf{g}_{sp} = 6.4 \times 10^{-7} \text{ 1/s}. \quad (5)$$

This value can then be compared with the theoretical \mathbf{B}_{sp}^{CW} field of Eq. 1, where the spatial decline of this field needs to be taken into account. The second gyro is at a distance $d = 7.5 \times 10^{-2}$ m. Eq. 1 needs to be adjusted with respect to both the material and the geometry of the gyroscopes. Inserting the quantities from the experiment into Eq. 1 delivers the theoretical value for \mathbf{B}_{sp}^{CW} at the center of the ring.

$$\mathbf{B}_{sp}^{CW}(0) = 0.328 \alpha \alpha_{sp} \frac{6m_e}{m_p} \frac{\rho A}{\rho_o A_o} \boldsymbol{\omega} = 3.04 \times 10^{-5} \text{ 1/s} \quad (6)$$

where ρ denotes the density of Si (quartz spheres used in GP-B), ρ_o is the density of Nb, A is the cross

section of the sphere, A_o is a reference area, i.e., for the sphere $A = \pi r^2$. Assuming that the field at distance d is that of a dipole

$$\mathbf{B}_{sp}^{CW} = \frac{r^3}{(r^2 + d^2)^{3/2}} \mathbf{B}_{sp}^{CW}(0) = 4.5 \times 10^{-7} \text{ 1/s}. \quad (7)$$

In GP-B, two pairs of gyroscopes were used, with a gyro separation distance of a few centimeters. Analyzing the GP-B experiment in 2008^[9,19] by employing the concept of extreme gravitomagnetic fields, it turned out that an *interaction between the gyros in each pair* should have occurred. The gravitomagnetic field generated by one sphere would be acting on the second one and vice versa, leading to a noticeable *spindrift anomaly*. In this case, a rotation of the gyro axis in the plane *perpendicular to its orbital plane* should have occurred. The spindrift magnitude is given by $1/2 B_{sp} \sin(\psi)$, where ψ is the misalignment angle of the gyroscope (the gyroscopes are initially oriented toward the guide star IM Pegasi).

The four solid curves in Figure 7, depicting the observed drift rate in as/day as recorded by the gyroscopes, and are taken from the Stanford-NASA Gravity Probe B space flight experiment data^[9]. The curves show the *measured misalignments* of the four gyroscopes employed in this experiment. The gyroscopes are operated at superconducting temperatures using liquid helium.

The two dotted curves in Figure 7 show the theoretical misalignment of the gyros as *calculated by EHT*. Calculations are based on the presence of an extreme gravitomagnetic field, which, according to *EHT*, results from the rotation of the cryogenic Nb coated quartz spheres. This gravitomagnetic field, being about 18 orders of magnitude larger than classical relativistic frame-dragging as predicted by *GR* (General Relativity), is outside *GR* and thus denotes a novel physical phenomenon. More details of the calculations can be found in^[19].

The Gravity Probe-B experiment might also provide indirect evidence for the existence of extreme gravitomagnetic and gravity-like fields because of the unforeseen anomalous misalignment found in the individual gyroscope results. The dotted curves represent maximum and minimum drift values, due to what is called *spin-spin interaction* between gyroscopes. Theoretical values were obtained from *EHT* that predicts the existence of *two additional gravity-like fields* acting in circumferential direction,

slowing down or accelerating a gyroscope. However, theoretically, conservation of angular momentum for the total of four gyroscopes should be maintained. According to *EHT*, a substantial part of the observed gyroscope anomaly should be due to these additional gravity-like fields, and should not be fully explainable by the four known physical interactions, i.e., electrostatic effects. In Figure 7 the gyro drift rate (vertical axis) is plotted versus angular misalignment. The drift accounts for the motion of the gyro axis, which may be caused by numerous (unknown) effects, including the two relativistic drifts of interest, which, are, however, tiny in comparison to the observed drift rate. Hence the denomination anomalous drift rate. This drift rate is resulting in increasing angular misalignment of the gyro axis with respect to the direction of the guide star. Initially the gyro axis was pointing at the guide star, whose direction is referenced by the onboard telescope. Due to relativistic precession, according to experiment, the gyro axis would be subject to a small angular misalignment, accumulating over measuring time (this was the reason for the large amount (2,240 \square) of liquid He on board the spacecraft), allowing to

operate the gyros for about 10 months. However, F. Everitt, the principal investigator of GP-B^[10], cites the presence of interacting electrostatic patches on the rotor and housing as cause for the drift anomalies, but, even when this effect existed during the measuring period, extreme gravitomagnetic fields might have been generated as well, and the two effects could have been present simultaneously.

If a spinning sphere (gyroscope) does generate an extreme gravitomagnetic field of similar magnitude as observed by Tajmar et al., this should be leading to an observable torque, causing a substantial frame-dragging effect resulting in a spindrift (west \rightarrow east drift). The second effect that should have occurred, would cause a gravitomagnetic force in tangential direction, *slowing down one sphere and accelerating the other*^[19].

This, in principle should have led to an effect *much larger* than the Lense-Thirring effect produced by the rotating *Earth*. It is most interesting to note that the latest (and definitely final) experimental results from the Stanford GP-B team, presented at NASA HQ on 4 May 2011^[11], for the geodetic and frame dragging measurements follow an unmistakable trend. Even

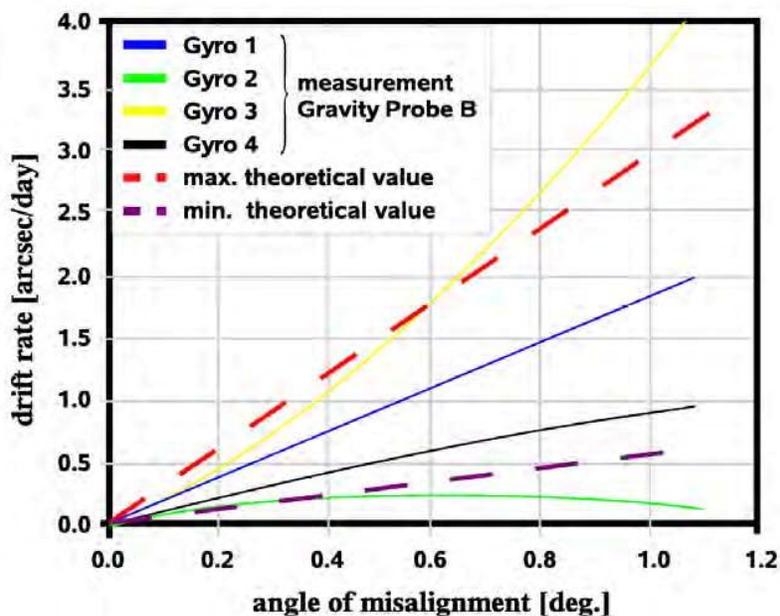


Figure 7 : Possible experimental evidence for novel gravity-like fields. The figure shows an overlay of two pictures. Solid curves were recorded by the gyroscopes, dotted curves are calculated results assuming the existence of extreme gravitomagnetic results as predicted by *EHT*. It should be noted that the anomalous drift rate for the individual gyroscopes is given in arc-second per day, while in TABLE 7 the frame dragging effect, i.e., the actual signal is about 39 mas/yr (1 mas/yr = $10^{-3}/365$ as/day = 2.7×10^{-6} as/day). To extract the frame dragging signal from the actually measured drift rates, required the application of highly complex mathematical procedures^[10], and thus it is understandable that the data analysis took more than five years. For more details see text.

the small values of the frame dragging, which were extracted from a noise background orders of magnitude larger than the actual signal magnitude, clearly show that in both gyroscope pairs (i.e., gyros 1-2 and gyros 3-4) one of the gyros is accelerated while the other one slowed down, but total angular momentum seems to be conserved. This could be interpreted as a sign that the torques predicted by *EHT* actually took place, leading to this behavior.

TABLE 1 : This table, taken from Everitt et al.^[10], shows the latest and final results for the geodetic and frame dragging data as extracted by the Stanford evaluation team after five years of data analysis. The reason for the complicated data evaluation procedure was an unforeseen major spindrift of the individual gyroscopes that was much larger than the actual frame dragging effect. Comparing the data between the two gyro pairs (gyros 1-2) and (gyros 3-4) it is obvious that one of the gyros was slowing down and the other one speeding up, i.e., an interaction between the two gyros in each pair had occurred.

GP-B gyroscopes	Value mas/yr	Frame Dragging mas/yr
Gyroscope 1	-6588.6 ± 31.7	-41.3 ± 24.6
Gyroscope 2	-6707.0 ± 64.1	-16.1 ± 29.7
Gyroscope 3	6610.5 ± 43.3	-25.0 ± 12.1
Gyroscope 4	-6588.7 ± 33.2	-49.3 ± 11.4
Joint value	-6601.8 ± 18.3	-37.2 ± 7.2
GR prediction	-6606.1	-39.2

From the GP-B data alone, however, it *cannot* be presently concluded that this theoretical effect actually occurred, though there might be room for it.

The Stanford evaluation team attributed the misalignment (solely) to an electrostatic patch effect, i.e., the surfaces of the Nb spheres, not being perfectly spherical, would have exhibited slight deviations from an equipotential surface, thus leading to (random) electrostatic forces.

GRAVITOMAGNETIC INTERFERENCE WITH NEUTRONS

In 1974 H. Rauch^[12,13] succeeded to demonstrate the interference with neutrons, whose wavelength is much smaller than the wave length of electrons that were used in the Aharonov-Bohm effect, already mentioned above. Despite the fact that neutrons are *not* elementary, i.e., they are composed of three quarks (u,d,d), in interference experiments they behave according to the hypothesis of de Broglie. In this experiment an interferometer of about 8 cm was used comprising a perfect single silicon crystal as

shown in Figure 9. A monolithic^[31] design is needed, because the parallelism of the reflecting lattice planes must be guaranteed within a fraction of their lattice distance in order to achieve coherent beam splitting. By means of these interferometers thermal neutrons can be split, reflected, and superimposed. As was already foreseen by Rauch, phase shifts can be produced by material, electromagnetic, and also gravitational interactions or, more generally, by any interaction that produces a potential or changes the canonical momentum of the particle. The advantage with this experiment is the wide separation of the partial beams. The gravitomagnetic field as generated by Tajmar et al. has at least an extension of several *cm*, the Nb ring has a diameter of 15 cm. If the beams need to be too close together, they cannot be influenced separately. The type of interferometer shown (top view) in Figure 9 is only one of several different versions of interferometers. The version that would be used in an actual gravitomagnetic experiment might have a different shape.

According to the Bragg equation part of the incoming beam (from the left in Figure 9) is deflected by an angle 2θ . Thus the partial waves are separated by the double Bragg angle θ . The thickness of the crystal planes has to be selected such that the two partial waves have the same amplitude. At the second plane each partial wave is split again, but only the refracted part is depicted. At the third plane the partial waves interfere and are registered. In general, thermal neutrons with a wavelength of about 10 - 40 nm are used.

SUMMARY FOR GRAVITY-LIKE FIELD EXPERIMENTS

In the experiments by Tajmar et al. a cryogenic rotating Nb ring is used to (possibly) generate an extreme gravitomagnetic or azimuthal gravity-like field. The governing experimental parameters are temperature T , angular velocity ω , and material composition. Below a certain critical temperature T_c an axial gravitomagnetic field is observed. The strength of the field is reported to depend on the sense of direction of the ring or disk. When the ring is rotated clockwise the field is about a factor five larger than in the counter-clockwise direction. If the ring is subject to angular acceleration, an azimuthal acceleration field counteracting the mechanical acceleration of the disk seems to be generated.

Tajmar also applied an external magnetic field in order to generate an axial acceleration field, which was, however, was *not* observed. According to *EHT*, a time derivative of $\frac{\partial \mathbf{B}_{gp}}{\partial t} \neq 0$ field should give rise to an azimuthal acceleration field. But simply applying an external magnetic induction field \mathbf{B} cannot, at least not according to *EHT*, generate an *axial* acceleration field. The only parameter that is available in Tajmar's experiments is the angular velocity. Of course, different ring or disk materials can be tested, but it seems that either Pb or Nb should be present. The liquid He does not seem to be responsible for the extreme gravitomagnetic fields. The same applies to the experiment by Graham, except that the aforementioned parity violation is reversed. The Gravity-Probe B experiment operates four Nb coated quartz spheres at cryogenic temperatures. The interesting fact is that initially the quartz spheres were rotating at the same angular velocities (frequencies). After the end of the measuring period of about ten months, two spheres were rotating at lower and the other two at higher frequencies. It

seems that an interaction between the spheres took place, slowing two spheres down and accelerating the remaining two. This can be interpreted as the action of an azimuthal force of the gravity-like fields that should have been generated by the cryogenic spheres themselves.

According to *EHT*, it should also be possible to generate an *axial acceleration* field^[17] (more details can be found in^[2]). Hence, the proposed Heim experiment aims at the generation of such an axial field by utilizing a cryogenic Pb solenoid above which a cryogenic carbon disk (mixed with a second material) is rotating. There is, however, one important point, because, the experimental conditions must be chosen to ensure the generation of a current of *real-imaginary Cooper pairs*. It should be remembered that imaginary Cooper pairs are being formed by pairs of $e - e_i$, which are essential for extreme gravitomagnetic fields to be produced, i.e., in the conversion process of electromagnetic into extreme gravitomagnetic fields. In this experiment a radial component of the gravitomagnetic field is also produced.

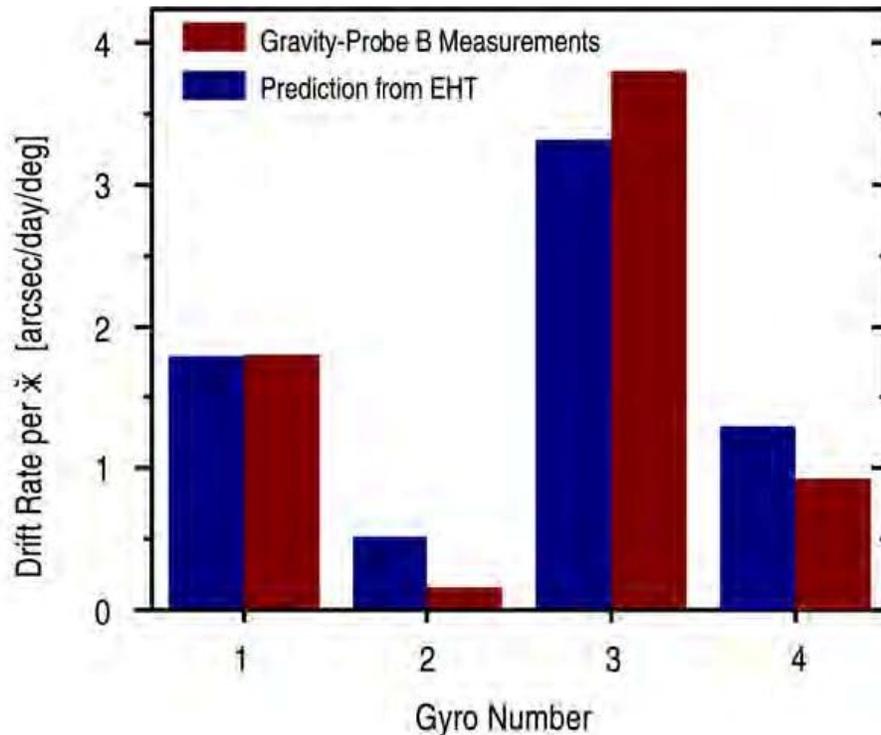


Figure 8 : Comparison of measured misalignment values of Stanford-NASA Gravity Probe-B experiment. Left picture shows an overlay of measured (solid lines) and maximum and minimum calculated drift rates as obtained from *EHT*. Right: Comparison of measured misalignment values for each of the four gyros of Stanford-NASA Gravity Probe-B experiment with predictions from *EHT*.

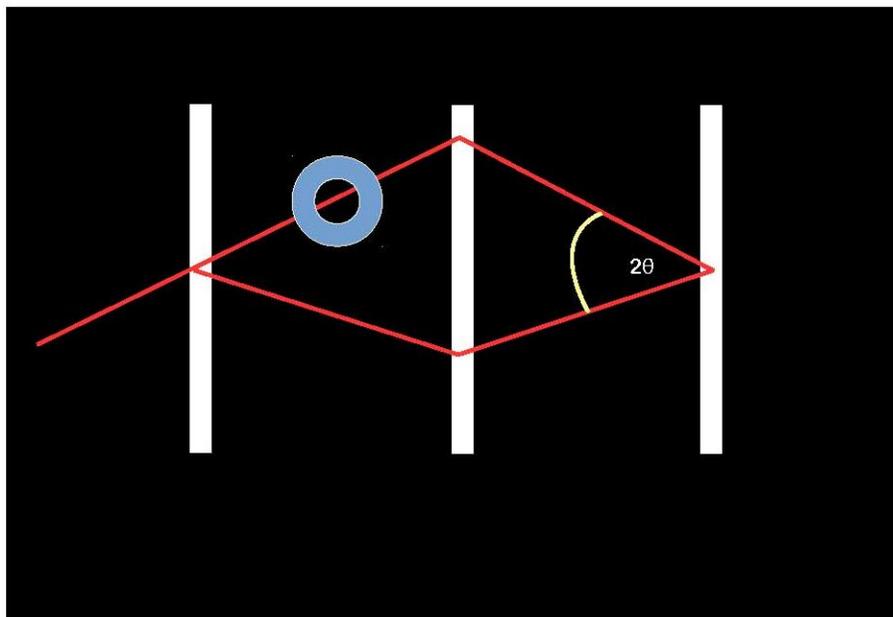


Figure 9 : Wave character of neutrons, first demonstrated by H. Rauch in 1974. Instead of an electromagnetic vector potential A the extreme gravitomagnetic potential A_{gp} will be used, leading to a *gravitomagnetic* Aharonov-Bohm effect (as suggested to M. Tajmar by the author). That is, the wedge is replaced by the A_{gp} field, while the left path is subject to a much weaker gravitomagnetic field, and thus a phase difference will be produced. A detailed analysis has to show, whether the predicted field strength is sufficient to produce a detectable phase shift. The ring (upper left) denotes the asymmetric position of the gravitomagnetic potential A_{gp} .

Concerning the Gravitomagnetic Aharonov-Bohm (GAB) effect it is very interesting to see that there exist already Aharonov-Bohm nano rings, for instance, at the University of Warwick, U.K., see the video at <http://www2.warwick.ac.uk/newsandevents/news/quatumdoughnuts> (accessed 8 Dec. 2012). It is of course, at least at the moment, pure speculation to think that these nano rings could be employed to measure the *GAB* effect. However, the Rauch interferometers seem to be a genuine option, because of the spatial separation of the split neutron beams.

CONCLUSIONS

Any breakthrough in propulsion physics or energy generation does require a breakthrough in gravitational physics. If gravity were completely described by Newton's law, as current physics assumes, then there is no possibility in achieving this goal. To this end, a set of recent *eleven experiments* was identified and discussed by W. Dröscher^[1] that, in some way or another, contradict established physical theories, in order to demonstrate that current physics has fundamental shortcomings. At

present, even the number of fundamental interactions is not known that is, there is a belief only that four interactions comprise all of physics. There is no classification scheme (in form of symmetry groups) that predict all of the particles (fields) and physical interactions that can exist in *Nature*.

As a result of W. Dröscher^[1], it was found that not only *GR* and the standard model of cosmology (measurements by McGaugh, no dark matter inside galaxies, existence of dark energy) are unable to explain these recent observations, but also the standard model of particle physics cannot be complete, since, for instance, Einsteinian gravity cannot be included and neutrinos are required to be massless etc. However, also the so called advanced theories (e.g. string theory, supersymmetry, quantum gravity, higher dimensions etc.) seem to be at odds with some of these recent experiments. In particular, the LHC has remained silent (no new particles), which clearly is in contradiction to the particle predictions of these theories.

In particular, any experiments that are measuring extreme gravitomagnetic fields are clearly outside *GR* as well as all of the advanced physical theories.

Since, however, the results of the eleven experiments, discussed in^[1], have shown that the established theories of physics cannot account for these novel physical facts, e.g. the MOND hypothesis is now experimentally verified, or even contradict recent measurements (e.g. there is a clash between supersymmetry and LHC data), it is obvious that current physical laws need an extension. In particular, the role of gravity is not (at all) completely understood. For instance, if there is an interaction between electromagnetism and gravitation, a new type of gravitational field might be generated.

This paper therefore addresses the possible reality of novel gravity-like fields outside *GR*, i.e., not produced by large static or moving masses. The approach chosen in this paper is unique, since the discussion is focused mainly on experiments and measured results, while novel theoretical concepts are employed in their interpretation only. In particular, those recent experiments (Tajmar et al., Graham et al. as well as GP-B) that might have generated extreme gravitomagnetic fields by small rotating masses at cryogenic temperatures have been analyzed and interpreted. In numerous experiments, first published in 2006, Tajmar et al.^[3-7] reported on the measurements of *extreme gravitomagnetic fields* produced by small rotating Nb rings at cryogenic temperatures that are up to 18 orders of magnitude larger than predicted by *GR*.

These three experiments were analyzed in detail to find out whether extreme gravitomagnetic or gravity-like fields might have been generated by rotating rings, disks, or spheres operated at cryogenic temperatures. A qualitative and quantitative analysis was performed and comparisons of measured data with a theoretical model termed *Extended Heim Theory*.

The physical analysis also addressed those phenomena that cannot be explained by the assumption of acoustic noise that might have been mistaken for the presence of extreme gravitomagnetic fields. It was shown that a consistent physical explanations for the reported phenomenon of parity violation can be provided, not only observed by Tajmar et al., but also seen in the experiments by Graham et. al as well as in the Gravity-Probe B (NASA-Stanford University)

experiment. It is argued that the anomalous phenomena observed in these experiments can (to a large extent) be explained by the existence of extreme gravitomagnetic fields. Based on these results it is concluded that the assumption of the existence of extreme gravitomagnetic fields provides a more probable and conclusive hypothesis than other current explanations in the form of acoustic vibrations (Tajmar et al.) and electrostatic patch effect (GP-B).

In particular, the two other gravitomagnetic experiments, namely the measurements by Graham et al. were not subject to acoustic noise, since the laser interferometer used by Graham et al. has a footprint of about 20 m × 40 m, and the Nb coated quartz spheres employed in the GP-B experiment could not cause any acoustic vibrations. Furthermore, there are additional anomalous effects in the Gravity Probe-B experiment, i.e., the spindrift and the tangential accelerations of the four gyroscopes (which are Nb coated quartz spheres).

Despite these arguments, the experimental situation cannot be considered conclusive, since, at present, there is *no* unique proof for the existence of extreme gravitomagnetic fields from this set of three experiments. Following standard scientific practice, these experiments (at least not until final clarification is reached) *cannot be cited as proof* for the existence of extreme gravitomagnetic fields, or be used as experimental support for novel physical ideas, for instance, as postulated by *EHT*.

However, it seems to be justified to state that there are numerous experimental facts that hint at the possible existence of completely new physics, including the existence of extreme gravitomagnetic and gravity-like fields, which would be outside both *GR* and the standard model of particle physics as well as the so called advanced physics beyond the standard model. Further experiments are needed for confirmation as suggested in Sec. II, to unequivocally decide on the generation of extreme gravitomagnetic fields in the laboratory. In particular, one can argue that there are hints both from experiment and theory that gravity might have a more complex nature than described by Einstein's theory. If this were the case, this would not only lead to a quantum leap in physics and cosmology, but a completely different technology based on gravitational

engineering might become reality. The features and consequences of such a technology are vividly described in the accompanying paper of G. Daigle^[21].

ACKNOWLEDGMENTS

This paper is dedicated to the venerable *Prof. Hozumi Gensho Roshi*, Hanazono University, Kyoto, Japan, whose teisho (teachings) on the nature of space and time have been a source of inspiration over the years. I am very much indebted to my colleague and longstanding co-author *W. Dröscher*, *Institut für Grenzgebiete der Wissenschaft (IGW)*, *Innsbruck, Austria* for many discussions and exchange of ideas that resulted in this paper.

The author is very grateful to *Prof. M. Tajmar*, *TU Dresden, Germany* for numerous discussions and explanations regarding his gravitomagnetic experiments.

The author is most grateful to *Prof. P. Dr. Dr. A. Resch*, director of the *Institut für Grenzgebiete der Wissenschaft (IGW)*, *Innsbruck, Austria* for his support in writing this paper.

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- [22] In *GR* there also exist gravitomagnetic fields, which are, however, so weak that they cannot be measured in a laboratory on *Earth*. For instance, the mass of the Nb ring used by Tajmar et al. was about 4×10^1 kg and measuring time was a few seconds. On the other hand, in GP-B, the experiment that attempted to measure the gravitomagnetic field caused by the rotating *Earth*, the mass is 6×10^{24} kg and measuring time was 10 months, but the effect was hardly detectable.
- [23] The claim was made by Dr. E. Davies, Institute of Advanced Studies, Austin, TX to the author. However, Prof. M. Tajmar, in a subsequent e-mail to the author, rejected this claim.
- [24] *Note:* As scientist the author honors truth and tries to be as impartial as possible in presenting the different interpretations of these experiments, although *EHT* does predict the existence of extreme gravitomagnetic fields.
- [25] These remarks are partly taken from the slides of a presentation given by M. Tajmar during the visit of the author at the Institute of Aerospace Engineering, TU Dresden, July 2012.
- [26] The topics on this list were identified with the help of Prof. M. Tajmar, TU-Dresden, Germany.
- [27] *Note:* There is the possibility that double imaginary Cooper pairs ($e_i^- e_i^-$) could be responsible for the extreme gravitomagnetic fields in the experiments of Tajmar et al., and imaginary imaginary Cooper pairs ($e^- e_i^-$) are generated in the proposed Heim experiment, leading to substantially stronger B_{gp} fields in the Heim experiment. However, this topic is still under investigation at present.
- [28] *Note:* The eight-dimensional internal gauge space H^8 used in *EHT* gives rise to a poly-metric tensor, whose sub-tensors (also called Hermetry form, i.e., the physical meaning of geometry) are representing physical particles (fields) and interactions, extending the mono-metric concept of Einstein (graviton, gravitation) to a genuine poly-metric that is deemed to account for all particles and interactions of physics, and in this way the geometrization of physics might be achievable.
- [29] *Note:* In this equation Gaussian CGS units are used so that \mathbf{B} , \mathbf{H} , and \mathbf{M} are expressed in the same units. It is assumed that $\mathbf{M} \sim \mathbf{H}$.
- [30] *Note:* The gyroscopes are coated with Nb and operated below the superconductivity temperature of Nb (9.2 K). Because of the London moment, a magnetic induction field \mathbf{B} occurs, which is parallel to the angular momentum vector \mathbf{L} . This \mathbf{B} field serves to provide a direction in space that can be aligned with the guide star, and thus a local coordinate system in space can be defined for the satellite.
- [31] Monolithic means the crystal is made from a single block of silicon.