Earth Natural Magnetic Resonances in Quantum Gravity Experiments

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Abstract

Nuclear magnetic resonances in the Earths oceanic waters that involve about 10^{+35} coherently precessing protons have been observed. This natural phenomena may exhibit effects that reside at both quantum and gravitational scales. Here we discuss a possibility of experimental measurement of an asymmetry of the gravitational field created by a polarized quantum particle by analyzing a correlation between the discovered oceanic proton resonances and data from existing gravitational wave observatories.

1 Introduction

Experimental searches for quantum gravity effects were not successful so far. The main reasons for this is a gap between the scales at which gravity and quantum processes are substantial. Gravity requires many kilograms of matter to produce detectable forces, while quantum effects are typically observed in individual particles weighting 10^{-27} kilograms.

One of the ways to overcome this difficulty is to find a situation where a very large number of quantum particles will exhibit the same quantum property and will contribute in the same way, or coherently, to a detectable effect. In most substances, quantum particles are largely affected by thermal interactions which leads to a random incoherent contributions of their individual intrinsic quantum properties, resulting in what we observe is a classical behavior. Under some conditions, however, this may change.

For example, in a well-established magnetic resonance imaging (MRI) technology, hydrogen atoms - protons, that are part of our tissues, are placed in a strong external magnetic field, which causes a macroscopic amount of them to become aligned in the same direction. Then a short radio wave pulse is applied to start proton spin precession, or rotation, around the direction of the magnetic field. The protons will precess coherently - the polarization direction, phase and frequency will be the same for all involved particles. Because each proton creates a magnetic field associated with its spin, coherent precession results in macroscopic oscillating magnetic field that is easy to detect.

The key concept of the present work is to search for an asymmetry of a gravitational field associated with the intrinsic spin of a polarized quantum particle. When a large amount of quantum

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particles is polarized in the same direction, the asymmetry - if it exists - of the gravitational field associated with the intrinsic spin of individual particles will accumulate into a macroscopic gravitational field, in a manner similar to the macroscopic magnetic field. In the case of magnetic resonance, macroscopic gravitational field will oscillate with the same pattern as the macroscopic magnetic field, making possible a selective search for the effect.

We found that magnetic resonances are occurring not only in the laboratory, but also as frequent large-scale events in our Earth oceanic waters. It is a unique phenomena by itself, as each such event involves nearly astronomical amount of 10^{+35} coherently precessing quantum particles. If proton's gravity has significant asymmetry linked to its spin, then it will be possible to detect its oscillations thousands kilometers away in already operating [1,2] gravitational wave observatories.

Because classical General Relativity does not predict, at a detectable level, gravitational waves from polarized particles, finding a correlation between magnetic resonances in oceanic waters and data from the gravitational wave detectors may provide new information about space-time structure.

2 Proton Magnetic Resonance in Oceanic Waters

Our hypothesis is that thunderstorm lightning discharge causes hydrogen atoms - the protons, contained in the surrounding oceanic waters and atmosphere, to precess at Larmor frequency defined by the Earth background magnetic field. The main argument towards it is that a powerful electromagnetic pulse from lightning above the oceanic water must cause a massive proton precession at 2 kHz. Within 100 km radius and deep sea waters, about 10^{+16} kg of hydrogen will be exposed to the lightning discharge pulse. With polarization level of 10^{-8} in the Earth magnetic field, 10^{+8} kg of protons will be involved in the precession. Estimation of electric field amplitude E from the protons' total magnetic moment M oscillating at cyclic frequency ω at a distance r is given by magnetic dipole radiation formula [3]:

$$E = \frac{Z_0}{4\pi} \frac{\omega^2}{c^2} \frac{M}{r} \tag{1}$$

where c is the speed of light and Z_0 is vacuum impedance. At $\omega/(2\pi) = 2\,10^3$ Hz and $r = 10^6$ m, the amplitude E will be $3\,10^{-5}\,\mathrm{V/m}$, or $30\,\mu\mathrm{V/m}$. Electric fields with such intensity can be measured by most radio waves receivers.

Intensity of electromagnetic waves from the resonance is comparable to the Earth magnetic field in the event area and hence may cause non-linear effects.

2.1 Experimental Verification

We conducted a one-week measurement of background electric fields in a remote location of North-West coastal area of British Columbia, Canada. Accumulated raw data is freely available at [8]. Our conclusion is that protons precess in large amounts and at Larmor frequency defined by local magnetic fields. Resonances at 2 kHz are visible, as for example shown on Figure 1 and Figure 2, and within the expected electric field amplitude range.

One common property of all observed resonances was a higher oscillation frequency at the beginning that gradually decreases to the asymptotical constant value with the time. Typical decay times were 10 milliseconds. The easiest way to explain it is a presence of additional magnetic fields at the beginning of the resonance, such as the non-linear effects mentioned above or magnetic fields from the lightning induced eddy currents. There are also strong electrical fields in the area that could be considered in the explanation of the effect.

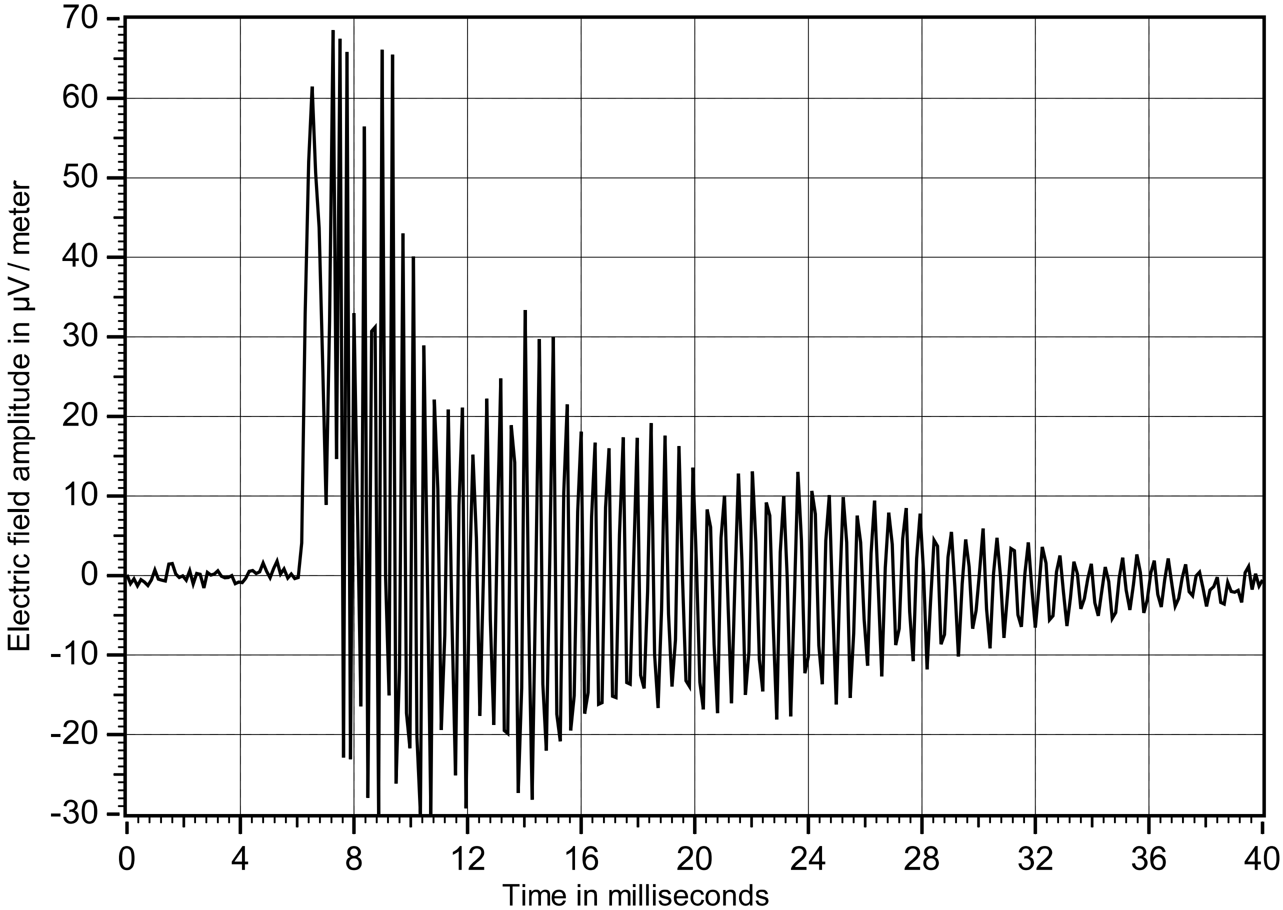

Figure 1. Proton resonance oscillations induced by lightning. Electromagnetic field recorded several thousand kilometers away from the event. The intensity of the radiated waves leads to an estimate of $2\,10^{+35}$ particles, or $3\,10^{+8}$ kg, of protons involved. The final oscillation frequency is 1.9 kHz, corresponding to the Earth magnetic field of $45\,\mu$T. Registering equipment was in the $56\,\mu$T zone.

In total 2 hours were recorded and contain about 1000 resonance events. The resonance frequencies of individual events were in the range from 1.6 to 2.3 kHz, which would correspond to the magnetic field strength at the site from 35 to 54 μT. To better see an average spectrum of individual event, background noise level and resonance width, each event was scaled in time so its frequency maximum will be at exactly 1, then square norms of complex electric field amplitudes were added together. The resulting spectrum is shown on Figure 2.

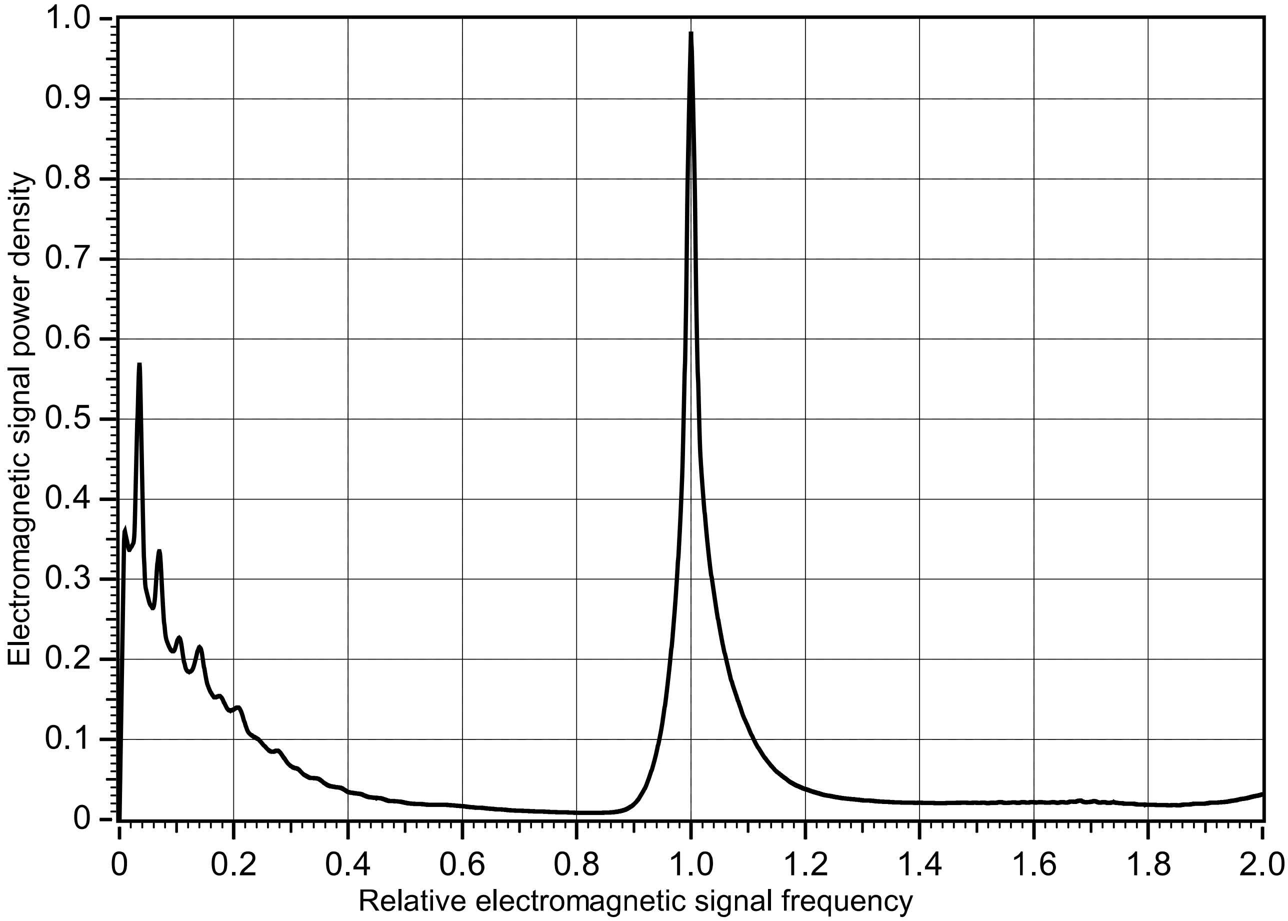

Figure 2. Spectrum density of an average lightning event. Electromagnetic radiation spectrum during lightning strike with resonance. It includes both the the resonance oscillations and the ambient noise, without cancellations based on the resonance phase. The narrow peak at 1.0 that corresponds to the original frequencies in the range from 1.6 to 2.3 kHz is what we believe to be the proton magnetic resonance in the Earth magnetic field.

Most likely the same resonance effects are happening with electrons and ions in the Earth atmosphere. The frequencies here will start at 1.3 MHz for electrons, and will decrease as the Earth magnetic field reduces with the elevation. In this work however, the electron resonances were not analysed.

2.2 Other ways to explain this phenomenon

Among radio operators, continues oscillations after lightning discharges are sometimes called tweeks and whistlers. They have been known for more than a century. There are theories to explain them based on radio wave reflections, signal attenuation, and trapping of waves in the ionosphere [4]. Our explanation above favors magnetic resonance of the source instead.

3 Expected Results

The specific of the proposed experiment is that we do not have a verified theory to predict the results. The best we can do is to use linearized classical General Relativity to calculate upper limit on the strain at the detector site from the $1/r$ law of the spherically symmetric Newtonian fraction. The applicable formulas are [6]:

$$g_{00} = 1 + h = 1 + \frac{2\varphi}{c^2}, \qquad \varphi = -\frac{Gm}{r}, \tag{2}$$

where g_{00} is a metric tensor component, φ is a classical Newtonian potential, r is a distance from a source to the detector, m is the total mass of involved protons, G is the gravitational constant and h is the strain estimate. Combining (1) and (2) together, the strain becomes defined by the electric field amplitude and its frequency only:

$$h = \frac{2G}{\pi Z_0} \frac{m_p}{\mu_p} \frac{E}{\nu^2} \tag{3}$$

where $m_p = 1.67\,10^{-27}$ kg is proton mass, $\mu_p = 1.41\,10^{-26}\mathrm{Am}^2$ its magnetic moment, E is electric field amplitude at the location where the strain is calculated, and $\nu = \omega/(2\pi)$ its frequency. For typical values $E = 30\,\mu$V/m and $\nu = 2\,$kHz, the strain upper limit is $h = 10^{-25}$.

The goal of the experiment is to measure the asymmetry in the gravity that is also propagating with the $1/r$ law and hence creates a similar strain. Per year, we have one to ten million lightning events, with about 50 oscillations per event. Statistical accumulation gives overall strain sensitivity threshold of 10^{-21} for one year of data accumulation. To compare, LIGO-Virgo-KAGRA Collaboration aiming to measure strain with sensitivity better than 10^{-23} [2].

Another estimation will come from radiated gravitational waves, that are also propagating with $1/r$ law, similar to the radiated electromagnetic waves. But it will have an additional factor of $1/\lambda^2$, where λ is the 150 km wavelength of 2 kHz oscillations, which makes them too small for detection.

Here we should note that using classical gravity theories for estimating effects from the intrinsic spin may be not always accurate. General Relativity is a tensorial theory: it uses metric tensor as the fundamental degree of freedom which leads to gravitational interaction. Spinors, on the other hand, are not directly compatible with this approach. Instead, to include them into the General Relativity, we imagine another, a simpler space where they can be mathematically defined, and use a formula (such as tetrad) to map gravity effects from Riemann manifold onto spinor space [7]. This leads to a stress-energy tensor of spinors in General Relativity and spherically symmetric $1/r$ gravity from them. While it may be a true structure of our nature, there could be other options, leading to different effects of interaction between spin and gravity. For example, if the true degree of freedom is the metric in the spinor space and the tensorial metric is only its representation, then the gravity will be more tightly coupled to spinors, leading to the gravity dependance on the particle polarization.

For Dirac spinors, the Larmor precession is observed as a changing in time expected value of spin operator $\vec{\boldsymbol{S}}$ [5]:

$$\langle \vec{\boldsymbol{S}} \rangle = \bar{\psi} \vec{\boldsymbol{S}} \psi \tag{4}$$

Hence when observed spin $\langle \vec{\boldsymbol{S}} \rangle$ and associated with it macroscopic magnetic field rotate at a frequency ν, spinor amplitudes ψ also rotate, but at the half of that frequency, $\nu/2$. If gravity is directly connected to spinors, rather than to their bilinear stress-energy tensor, then its main $1/r$ mode may also rotate at $\nu/2$, which would be possible to detect.

Hence, a detection of $1/r$ asymmetry or $\nu/2$ frequency of proton gravity fields may indicate that the gravity has spinorial degree of freedom.

4 Environment Monitoring

Another application of the magnetic resonances caused by lightning is a remote spectroscopical analysis of substances near the strike zone.

Gravitational and electromagnetic waves will accumulate different phases while travelling from the source to the detector. Hence measuring only the phase of the electromagnetic signals at the detector site is not sufficient. The source locations are also required, with the accuracy of about 10 km. This can be done by an array of conventional electromagnetic wave receivers within proximity from the main oceanic bodies. The obtained information can then be used to build a 3d map of magnetic resonance spectral densities, for both oceans and atmosphere.

5 Conclusion

An $1/r$ propagating asymmetry in a polarized quantum particle gravitational field, if it exists, can be measured using massive proton precessions in the Earth's oceanic waters. The present sensitivity level of existing gravitational wave observatories [1] resides within the best-case estimate of the detectable effect after a few months to a one-year period of measurements.

The experiment requires a set of electromagnetic field sensors located within reasonable proximity from major oceanic bodies to measure phases and frequencies of proton resonances for statistical cross-correlation analysis of data from gravitational wave detectors.

The equipment and technology developed for this experiment can also be used for remote spectroscopical imaging of the Earth's oceans and atmosphere.

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