Can a sub-quantum medium be provided by General Relativity?

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Emergent Quantum Mechanics (EmQM) seeks to construct quantum mechanical theory and behaviour from classical underpinnings. In some formulations of EmQM a bouncer-walker system is used to describe particle behaviour, known as sub-quantum mechanics. This paper explores the possibility that the field of classical general relativity (GR) could supply a sub-quantum *medium* for these sub-quantum mechanics. Firstly, I present arguments which show that GR satisfies many of the a priori requirements for a sub-quantum medium. Secondly, some potential obstacles to using GR as the underlying field are noted, for example field strength (isn't gravity a very weak force?) and spin 2. Thirdly, the ability of dynamical exchange processes to create very strong effective fields is demonstrated through the use of a simple particle model, which solves many of the issues raised in the second section. I conclude that there appears to be enough evidence to pursue this direction of study further, particularly as this line of research also has the possibility to help unify quantum mechanics and general relativity.

The Sub-quantum Medium

In emergent QM the sub-quantum medium is the field out of which quantum behaviour emerges. Most, if not all EmQM theories published to date do not explicitly define the nature of the sub-quantum medium, instead quite reasonably they only assume that some underlying field exists, having some minimum set of required properties, for instance some sort of zero point field interaction.

There have of course been investigations into the physical make up of a sub-quantum medium. Perhaps the most investigated possible source is stochastic electrodynamics (SED)[5]. Investigated on and off since the 1960s, SED posits the existence of a noisy isotropic classical radiation field as the zero point field (ZPF). stochastic electrodynamics as a sub-quantum media has many desirable properties. As an example of progress in stochastic electrodynamics Nieuwenhuizen and Liska[12] have recently used computer simulation techniques to build an almost stable hydrogen atom.

Yet classical electrodynamics has a few problems as the sub-quantum medium. Davidson points out that

> "A particle in SED gains or loses energy due to interaction with the zero point field. Atoms tend to spontaneously ionize in SED as a consequence. ... The spectral absorption and emission lines are too broad in simple calculations published so far to come anywhere close to fitting the myriad of atomic spectral data."[4].

Other sub-quantum medium proposals include Brady's compressible inviscid fluid - an entirely new classical field that is posited to underpin quantum mechanics and electromagnetism.[1]

This paper proposes a sub-quantum medium that is already experimentally confirmed and is somewhat surprisingly stronger and more flexible than usually thought - general relativity (GR). Using GR as the sub-quantum medium as presented here assumes only classical GR. Other proposals that are similar in some ways are Wheeler's geons of 1957 - constructed of source free electromagnetic fields and gravity under the laws of standard QM[11] and Hadley's 4-geons[8]. Hadley's proposal is perhaps the most similar to that here, but Hadley assumes the independent reality of an electromagnetic field. This paper instead uses only GR as the fundamental field.

General relativity has some qualities that lend itself to consideration as a sub-quantum medium:

1. Frictionless (inviscid):

   The movement of objects through empty space is observed to be frictionless, as waves and objects can travel long distances without measurable hindrance. GR's *ether* (such that it is) behaves as an inviscid media in its linear regime, allowing for this. Importantly, there is friction in situations such as Kerr hole frame dragging.

2. Covariant:

   Manifestly so.

3. Non Linear:

   This non - linearity allows for a rich variety of behaviour at small scales - a minimally explored, flexible platform to construct particles.

4. Coupling:

   General relativity couples to all material, uncharged or charged.

Potential Problems

How can general relativity form a basis for quantum mechanics, given the following:

1. Gravity is weak.

    GR is often thought of as a weak force, after all the electromagnetic force between two electrons is some 10^{42} times that of their gravitational attraction! But for the purposes of a sub-quantum media we are interested in large energy transfers (e.g. Grssing's[7] thermal ZPE environment), not the weak effects of gravitational attraction. Instead of $0Hz$ attraction effects, consider gravitational waves. Looking at optical frequencies ($10^{14}Hz$), for GR the maximum energy transfer rate before non linear effects start to dominate is tremendously high - about $10^{65}W/m^2$. Compare that to electromagnetism, where we have to appeal to something like the Schwinger limit which is only $10^{30}W/m^2$. Thus GR has plenty of room to host strong effects.

2. Gravity has a weak coupling.

    In order to model a quantum system (say a hydrogen atom), we require the quantum forces to be much stronger than the electromagnetic forces. Yet the coupling of gravity to the electron is much weaker than even the electromagnetic force. The solution to this problem lies in realizing that gravity can couple not only through '$0Hz$' effects but also through the exchange of wave energy. The *Possible Mechanisms* section below outlines how this could happen.

3. Gravity is quadrupole (spin 2).

    If we are to also generate EM from GR, we require a spin 1 field to emerge. Emergence is the key - underlying fields can give rise to apparent net fields of different spin. E.g. Monopole gravitational waves[9].

4. Bell's theorem and hidden variables.

    Using GR as the underlying medium to emerge quantum mechanics from would seem to have to satisfy Bell's inequalities - and thus disagree with current QM theory. Maldacena and Susskind's EP = EPR paper[10] is an example of a solution to this.

Possible Mechanisms

Here I investigate some consequences of purely classical geometric particle models that are the mass of the electron in a universe where the only field is classical general relativity. The exact micro structure of a particle is not of concern here, instead I look at some tools and building blocks with which to build elementary particles from nothing more than classical GR.

An electron like particle is modelled as a small region of space which has some geometric microstructure that results in a particle with the correct mass and spin. I will point out here that a Kerr solution with the mass and spin of an electron happens to have a (naked) singularity at virtually the Compton radius (1/13 the Compton wavelength).

Whatever the exact microstructure of an elementary particle, there is certainly extensive frame dragging occurring. Frame dragging is the 'handle' to which gravitational wave energy exchange can grip. As Brito et al. start their comprehensive 'Superradiance' paper:

> "Superradiance is a radiation enhancement process that involves dissipative systems"[3].

Superradiance in GR was introduced by Press and Teukolsky's 1972 paper *Floating Orbits, Superradiant Scattering and the Black-hole Bomb*[13].

This paper posits that EmQM's sub-quantum ZPF might be a run away superradiance effect (limited by non linear mechanics). Is the universe a black hole bomb?

This superradiant (and highly absorbing - see figure 1) energy exchange of the particle with its surroundings causes the particle to be subjected to huge forces - superradiance for example allows for a substantial fraction of the mass of a rotating black hole to change over time scales a few times the light travel time across the of the hole. The recent paper by East et al. studies black holes undergoing superradiance using a numerical method.[6]. It seems that the superradiance is on a knife edge with absorption - these effects happen at only slightly different frequencies.

While the time scale for a black hole with the mass of an electron is a tiny $10^{-65}s$, it seems reasonable to assume that the frequency for superradiance is tied to the distance scales involved in the particles structure, so there could be superradiant effects happing on different timescales. For instance, an effect at $10^{-65}s$ could be holding the particle together, while the forces of EM and the actions of QM might take place using waves closer to the electron Compton frequency.

Look now at a Compton frequency superradiant process. We have an energy exchange of some fraction of the mass of the electron happening at $1.2x10^{20}Hz$. The maximum force an effect like this

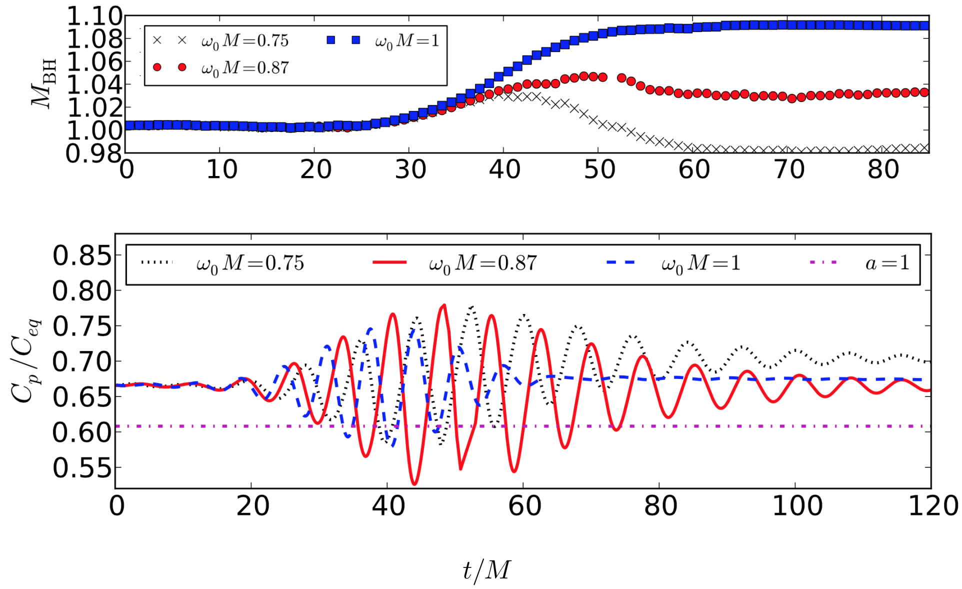

FIG. 1: From East[6]: Top: mass change over time, for incident gravitational waves with three different frequencies. $\omega_0 M = 0.75$ is superradiant, while $\omega_0 M = 1$ shows complete absorption. Bottom - shows the effect of the wave on the shape of the horizon - so the entire wave packet can be visualized.

can produce on an electron mass particle is of order 0.01 Newtons! Forces like this are surely strong enough to control the movement of the electron and phase lock it, giving rise to the sub-quantum force.

There is also a mechanism by which electromagnetic effects can emerge from such energy exchange. See Brady[2] section 4 for one simple method of calculating an electromagnetic force from mass exchange.

Discussion

The sub-quantum medium, whatever it is, has to behave so that quantum mechanics can arise from it. I hope that this paper has shown that General relativity covers at least some of the requirements for a sub-quantum medium. In order to fully test this idea, there might likely need to be an actual geometrical model of the electron found. The techniques of numerical general relativity could be the best tool to study these interactions in detail.

If the pursuit of an emergent quantum mechanics is to prove fruitful, then the idea that a field like general relativity does not hold on the microscale may have to be re-considered, as with EmQM there is no overarching 'quantum regime'. With general relativity still on the stage at $10^{-17}m$, Occam's razor perhaps suggests that we prove that general relativity is not the sub-quantum medium before a new field is invented.

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