Gravitational Axions in Quantum Gravity and Cosmology

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Abstract

A hypothesis was proposed for cosmic QCD axions as gravitational bosons within *quantum gravity*[1] – physical gravitational analogues of Goldstone bosons coupled to artificial Higgs mode excitations as known in condensed matter physics systems; essentially low mass, low frequency and low temperature bosons of either a single species, a distribution of particle mass, or spectrum of particle mass coupling.[2] The masses of the hypothetical dark matter particles are expected to be in the microwave region, and therefore it's possible the boson itself could be a mass mediator akin to a *gravitational gauge boson*.[3]

Extending these concepts to spacetime and gravitation, and thus cosmic axions and the quantization of gravitational forces and fields – *quantum gravity*, involves introducing the concepts of geometry and topology from condensed matter physics analogue systems, as references, into *quantum cosmology*.[4, 5] The purpose of this essay is to delve deeper into these new speculative quantum cosmologies based upon these concepts. Specifically, I will discuss the original concepts of axion f_a field dependencies, and microwave axions as electromagnetic mass mediators within infrared and optical state transitions.

Dark Matter Gravitational Axions

Gravitational axions are posited to be *cosmic* QCD axions, of the Peccei-Quinn variety, resulting from cosmological baryogenesis processes occurring shortly after the initial inflational era of the universe.[1] In addition to the Peccei-Quinn symmetry breaking behavior clearly delineating their existence as new standard model particles, it is further deduced that as well as their gravitational properties, axions are gravitoelectromagnetically active pseudo-bosons capable of unifying gravity with the standard model. This behavior is exemplified by their unusually large calculated effective masses within QCD theory, placing their mass within a few degrees of absolute zero and near the superfluid transition temperature of liquid helium at 2.172 K, and the frequency of the cosmic microwave background radiation or CMB. Low temperature microwave axions make detection possible within condensed matter physics analogue experiments at liquid helium temperatures, and within mixed liquid ^{3}He and ^{4}He experiments as well. Optically trapped ultacold atomic systems residing near the true quantum spacetime vacuum, combined with axion detection, elucidation and exploitation through their excitation and manipulation, will be the hooks into the physics of quantum continua and vacua needed to unify all the physical forces of nature.

Axions are Topological Remnants from a Cosmic Inflation of Fluctuating Spacetime Topology

Axion production is intimately related to ***C***, ***P*** and ***T*** invariance symmetry breaking[6] in the very early universe, resulting in a scale invariant expanding spacetime continuum imprinted with both dark and ordinary matter. Spacetime itself is globally very nearly flat, and mimics a Minkowski spacetime both locally and globally, absent of any topological effects such as large nearby massive objects in space.

Single nuclei and nucleons are considered to be topological defects within spacetime, since they have mass, charge, spin and spatial extent, and they gravitate. Those gravitational effects are overwhelmed by the vastly stronger Coulomb repulsion/attraction, the Pauli exclusion principle, and weak and strong forces. Gravity, which considering the existence of these apparent singularities within the universe, is in fact the strongest of all forces, and only in the dilute and weakly coupled limit is it the weakest force.

Quantum and macroscopic gravitational topological singularities observable in our universe consist of elementary and composite particles, spherical bodies of many gravitationally aggregated nuclei, orbits around these roughly spherical bodies, and roughly spherical black hole event horizons, which are the end products of cosmic evolution. In other words – back from whence it came. These products all represent particularly simple examples of the mathematics of spacetime topology, implied by the reduced 3+1 dimensional structure of our expanding Riemannian spacetime manifold in which our individual Minkowski spacetimes are embedded. The question then is why is global spacetime flat?

Evidence for inflation is clear from the cosmic microwave background radiation (CMB), whereas an irregularly dispersed string-web-void structure is imprinted upon the otherwise isotropic homogeneous spacetime, giving an appearance of a complex topology of a cosmogenesis event as it initially occurred. It is precisely this topological record of quantum baryogenesis that records the topology of fluctuating quantum spacetime at the quantum cosmogenesis event, in the global universal distribution of axions and baryons (dark matter and visible matter) in an otherwise flat and homogeneous expanding universe.

The complex topology now seen in the universe are the horizon as seen from the Minkowski light cone, and the uncountable black holes, in addition to the distribution of galaxies along web – void structures. The topology of black holes, absent merger events, is roughly spherical like every other gravitationally compacted baryonic object in the universe. The web – void distribution contains structures resembling point nodes, filaments and domain wall sheets, just like any other inhomogeneous 3D phase separated system such as seen routinely in condensed matter systems, where topology is dimensionally restricted.

The existence of a nanoscale phase separation structure embedded in spacetime is a clear indication that the initial event involved highly correlated spacetime – charge, spin, mass and energy transport. The pre-big-bang quantum cosmogenesis and inflation model clearly involves quantum topological superfluids with fluctuating geometry and topology, tuned to near and/or across quantum critical points, subject to the BCS-BEC (Bardeen Cooper Schrieffer – Bose Einstein Condensation) transition physics.

Associated with this scenario is a transfer of spectral weight (energy) across a large charge transfer gap, into a variety of pseudogap and in gap states, evolving through various locations in the phase diagram where the singularities known as these quantum critical points are hidden behind event horizon domes. The building blocks of these various quantum pseudogap and ground state phases are the fundamental particles of physics, bosons and fermions; Dirac, Weyl and Majorana, as well as various composite and collective constructions, projections and excitations composed of their superpositions and interactions.

The quantum spacetime vacuum and the dark matter were extraordinarily cold, and the baryogenesis produced a exceptionally hot and expanding relativistic fireball composed of a standard model quark gluon plasma condensed into these fields, which subsequently cooled off, only to be reignited again by gravitational aggregation. Assuming a universal axion angle value approaching an infinitesimally small value before global symmetry breaking and the resultant abrupt phase transition occurs, then the global phase strength and the attractive forces of the composite boson-fermion mixtures making up the initial quantum superfluid must have been very large indeed. Given an apparent horizon from astronomical observations, the energy released was, of course, immense; a fraction of it converted directly into mass.

Inflation reduced gravity to the weakest force in an expanding universe where particles could interact. The dark matter axions then emerged from this hot standard model early universe relatively unscathed, indicating that axion particle coupling at high energy is extraordinarily weak, due to their cosmological nature and their moderately low mass. However, once the universe cools into the microwave region and the electronic and gravitational interactions were turned on at larger scales by the actions of gravity and collisions, axions in the baryonic regions of space would begin to become aggregated and then excited, even for very weak gravitoelectromagnetic coupling. There is little reason to believe that this coupling would be weak, particularly near colder dense and heavy objects, since gravitational coupling is strong.

Therefore, the conclusion is that dark matter axions are gravitational spacetime topological remnants of the cosmic inflation, which produced the scale invariant universe in which we live, and are conformal particles resulting from the decay of spacetime topology after space inflated, and the axion angle was driven nearly to zero, where charge, parity and time reversal symmetry were broken, and the universe was thus born in the big bang baryogenesis event. The result was a superfluid like vacuum of inflating Minkowski space, and after the breaking of time reversal symmetry, a scale invariant universe of a dark matter excitation spectrum imprinted upon a plasma of the standard model's ordinary baryonic matter; now excited locally back to very high densities and energy. Therefore it is proposed here that the axions are primordial cosmic bosons, moderately gravitoelectromagnetically interacting, and physics unifying. The Peccei-Quinn symmetry breaking in QCD is mere relic from a time in the early universe where an energy gradient gave birth to space, time, mass, energy, charge, spin and particles in copious quantities, not representative of the coupling between dark matter axions and ordinary matter at lower energies.[7, 8]

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