Meet the Rottons – dark matter field quanta with irrational spin.

Abstract

In terms of the material nature of the universe we highlight the need for something beyond the Standard model of particle physics and suggest how recent work on continuous valued spin yields a solution.

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Introduction

The Standard Model of particle physics (SM) in a dynamical arena of 3 x space + 1 x time dimensions is the result of very many observations and theoretical developments in 20th Century physics and mathematics combined. The SM is a quantum field theory that comprises and describes entities associated with quantum numbers of mass, Coulomb electric charge/weak hypercharge, the color charge of Quantum Chromodynamics, the all-pervasive Higgs field and spin/angular momentum.

The spin quantum number is expressed in units of the reduced Planck constant, $h/2\pi = \hbar$ (h-bar), and the SM contains members from the set of spins equal to [0, 1/2, 1] x $\hbar$ (implicit from here onwards). There are two further spin categories [3/2, 2] available to SM objects that are not assigned to observed fundamental entities hitherto. For example, spin 2, massless and charge-free gravitons are the predicted force carriers of gravitational action in any string theory. Uncharged, spin 0 Higgs bosons, described by a symmetric wavefunction and where Bose-Einstein statistics apply, are known as scalar entities as they have rest mass. Spin 1/2 entities, for example charged leptons and uncharged neutrinos, are collected into the fermion class with anti-symmetric wavefunctions and where Fermi statistics and the Pauli exclusion principle apply. Finally, electromagnetic (photon), weak (charged W and neutral Z) and strong nuclear (gluon) force exchange bosons, are all spin 1.

The observed SM objects and their products make up approximately 4% of the universe's total mass/energy. The remaining 96% resides in the, so-called, dark sector. Dark matter accounts for about 26% and dark energy the rest, or about 70%, of the total. Dark matter is named for the extra material required to account for, amongst other phenomena, the observed rotation rates of galaxies and the gravitational lensing of remote galactic light. Dark energy is the placeholder for the driver of accelerated universal expansion, observed since 1998, and may simply reflect a positive cosmological constant in Einstein's equations of General Relativity theory.

As highlighted above, a need for something beyond the SM persists to account for the dark matter. In the case that dark matter is particulate, extensions to the SM involving supersymmetry – exchanges between the spins of bosons and fermions – are predicted to provide a candidate solution. Current and ongoing experiments, however, indicate that the discovery of supersymmetry will probably require particle accelerators beyond the Large Hadron Collider at current operating specifications. The model space in which to find the lightest supersymmetric partner particle – if indeed it is to be found – decreases with each experiment to date. There are many other active research areas associated with the hunt for dark matter but the idea here follows a separate and distinct line of reasoning.

Continuous valued spin

A significant theoretical research effort since the Kaluza-Klein extensions to General Relativity theory, and including string, M and F theories, has been expended in arenas with extra dimensions of space. In 2013, Philip Schuster and Natalia Toro at the Perimeter Institute[1] wrote down the quantum theory of objects with continuous valued spin on a 4 x space + 1 x time manifold. Their equation 101 encapsulates all instances of these objects.

The SM does not contain elementary objects of every conceivable mass and the extension here does not include all possible values of spin. Instead, we highlight distinct groups based around irrational-only spin values. This restriction is not severe since there are infinitely more irrational numbers than there are integers. However, after the strictest restriction is applied, where the Reimann Hypothesis is assumed as an axiom, the allowed remaining scope of spin values is, at most, countably infinite.

The first members of this new, continuous spin class have a spin value, s = SQRT(2) = $\pm\sqrt{2}$ is abbreviated as c-boson and its partner c-fermion takes the reciprocal value of this spin to yield, $s = 1/\sqrt{2} = \pm\sqrt{2}/2$ and we build a set with four members: $[\pm\sqrt{2}/2, \pm\sqrt{2}]$

Next, there is a set with eight members 6 x c-fermion + 2 x c-boson: $[\pm\sqrt{3}/3, \pm\sqrt{3}/2, \pm 2\sqrt{3}/3, \pm\sqrt{3}]$

Then there is a two member set of "Golden ratio" c-fermion objects: $[(1 + \sqrt{5})/2, |(1 - \sqrt{5})/2|]$

... and onwards involving other functions of prime numbers. We note that objects with spin s >= 2 are massless c-bosons and s is calculated analytically for each via:
$s = \pm n/4 \cot(\pi/n)$ where n is prime and n >= 7

It is emphasised that the c-bosons and c-fermions here are beyond the SM and only those with non-zero rest mass will be noticeable through their gravitational action on space-time.
As yet, we have learned almost nothing of the mass values of these c-spin class members but observations of the twin jets emerging from the proximity of highly curved space-time near gravitational black holes may provide further clues if the following reasoning holds true.

It is proposed that $s = \pm\sqrt{2}$ c-bosons and/or $s = \pm\sqrt{2}/2$ c-fermions emerge from spin 1 entities, e.g. those found in Hawking radiation, being stretched and reconfigured as they exit the curved space-time near black hole event horizons as oppositely oriented, s positive and s negative, streams. Consider, a plane right triangle has hypotenuse $\sqrt{2}$ but an equilateral triangle on the surface of a sphere may have 3 interior right angles and unit length sides as shown in Figure 1. Given a plane, tangential to the sphere and in contact at its north pole, we can uncurl the triangle such that unit sides and an enclosed right angle remain connected at the pole. However, to complete the triangle, the hypotenuse must now be stretched to a length of $\sqrt{2}$ units. A single $\pm\sqrt{2}$ c-boson or a pair of $\pm\sqrt{2}/2$ c-fermions would be the resultant products from such deformations.

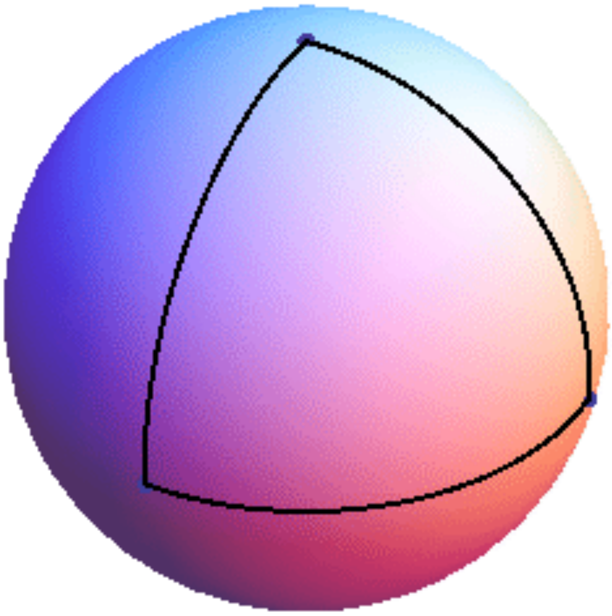

Figure 1: Equilateral triangle with 3 interior right angles on a sphere[2].

Conclusions

On first sounding, adding new spin categories to the Standard Model of particle physics is a crazy idea (after Sir Roger Penrose's request) presented here as a toy model. Aimed to shed light into a corner of the dark sector and hopefully described parsimoniously.

The model is a work in progress, a.k.a. the bumbling efforts of a retired Atmospheric Physicist and armchair cosmologist, after a refreshing catch-up study of Markus Luty's online lectures on quantum field theory[3] followed by reading Schuster & Toro.

The idea could be disproved by the absence of the predicted entities at energies up to the Planck scale. The discovery of supersymmetry in nature would probably render the idea moot. The decided absence of at least one extra, large dimension to space would be terminal.

If irrational spin is indeed the case in nature then a suitable name for the new, continuous and infinite precision spin class feels, sounds and looks something like, rotton.

References:

1. Philip Schuster & Natalie Toro, 2013, “A Gauge Field Theory of Continuous-Spin Particles”, https://arxiv.org/abs/1302.3225

2. Ted Bunn, 2014, “Spherical Triangles”, https://blog.richmond.edu/physicsbunn/2014/02/01/spherical-triangles/

3. Markus Luty, 2013, “Quantum Field Theory”, https://www.youtube.com/watch?v=EzfFklLqDjA&list=PLUU3fPO7nTeaV3q6OU1rBl3KX3rnECDFS