PENTAQUARK CHARGE - MASS/ENERGY ASPECTS OF PENTAQUARK PROCESSES & A NEW THEORY - GENERAL PROJECTIVE RELATIVITY (GPR)

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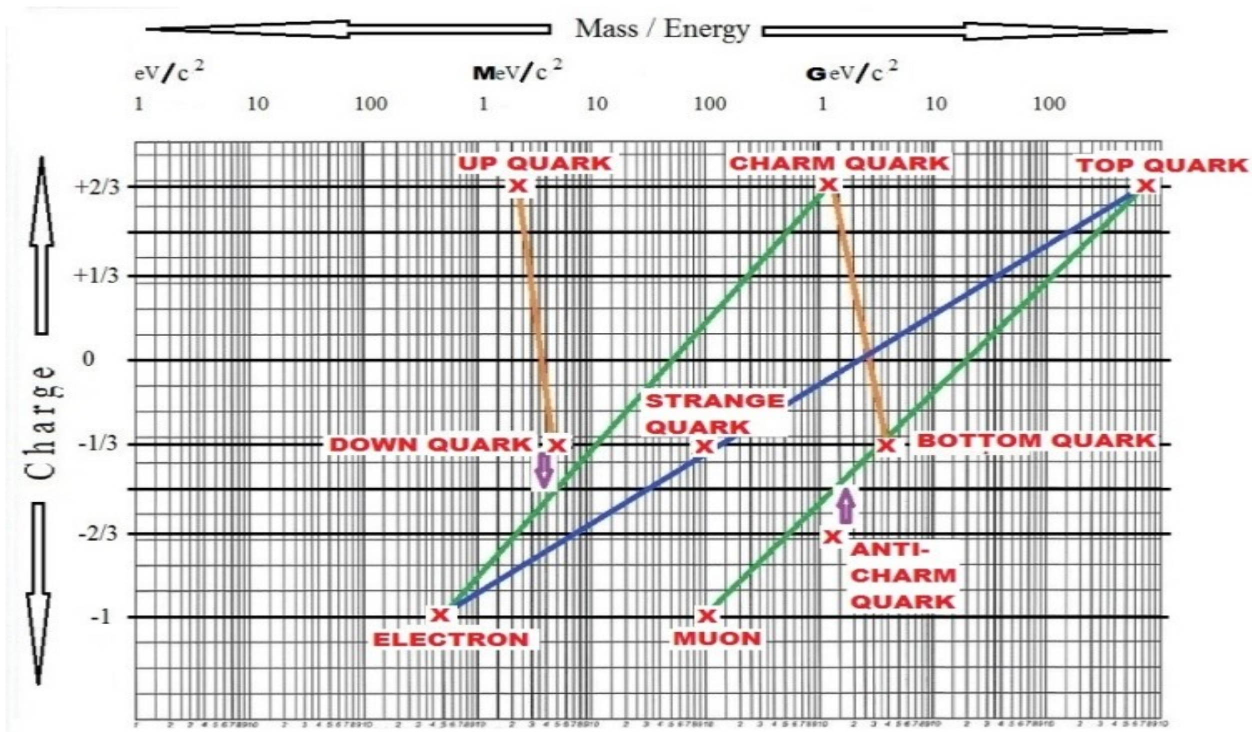
In 2015 scientists at the Large Hadron Collider (LHC) announced the first ever statistically significant observation of a “pentaquark” subatomic particle (R. Aaij, LHC_b collaboration, Phys Rev Lett 115, 072001, 12 August 2015). Such a “pentaquark” subatomic particle is allowed within the framework of quantum chromodynamics (QCD) theory which encompasses quark and gluon strong binding interactions. The “pentaquark” is an up-down-up-charm-anti-charm quark combination, i.e. five quarks, hence the name “pentaquark”. The hundreds of arXiv papers following pentaquark discovery mostly try to extend current QCD mathematics to explain the pentaquark. These explanations fall short of dealing with the networked processes of the pentaquark. This paper comes at the pentaquark from a higher level networked complex adaptive systems perspective. Ultimately this involves a new theory, General Projective Relativity (GPR), which is based on probabilistic computational entanglement in a projection geometry that goes beyond holographic and ultimately offers promise in furthering scientific knowledge across a wide spectrum including dark matter and dark energy.

The specific issues to be addressed with the “pentaquark”, and this paper, are:

1. Since the LHC observation contained two “pentaquark resonant energy states” at 4380.0 MeV/c^2 and 4449.8 MeV/c^2, what is the basis for these two states?
2. How is the “pentaquark” bound together? Is the binding strictly gluon quark to quark or is there a baryon up-down-up to meson charm-anti-charm binding aspect?
3. QCD theory for the “pentaquark” does not favor any particular “quark flavor” so why is it that the relatively more massive and less stable charm quark is part of the “pentaquark” mix?
4. In the context of a very large issue that extends beyond the “pentaquark” to all of physics, the LHC “pentaquark” observation is an observation of both bounded position and momentum aspects which mitigates Heisenberg uncertainty and entropic randomness, for which a new entangled computational information theory General Projective Relativity (GPR) explaining progression to complexity is proposed.

Subatomic particle mass/energies vary greatly. In the case of the “pentaquark” the mass/energies are up quark 2.3 MeV/c^2, down quark 4.8 MeV/c^2, and charm anti-charm quarks 1275.0 MeV/c^2. This points to mathematics at a logarithmic scale and hence this paper uses the following semi-log plot of subatomic particle charge versus subatomic particle mass/energy to shed light on the prior listed issues.



SUBATOMIC PARTICLES MASS/ENERGY vs. CHARGE

The prior diagram, which is at the visual and geometric end of the mathematics spectrum, has a great deal of utility. Isaac Newton realized the utility of such diagrams, and had well over 200 such visual and geometric diagrams in his seminal book The Principia.

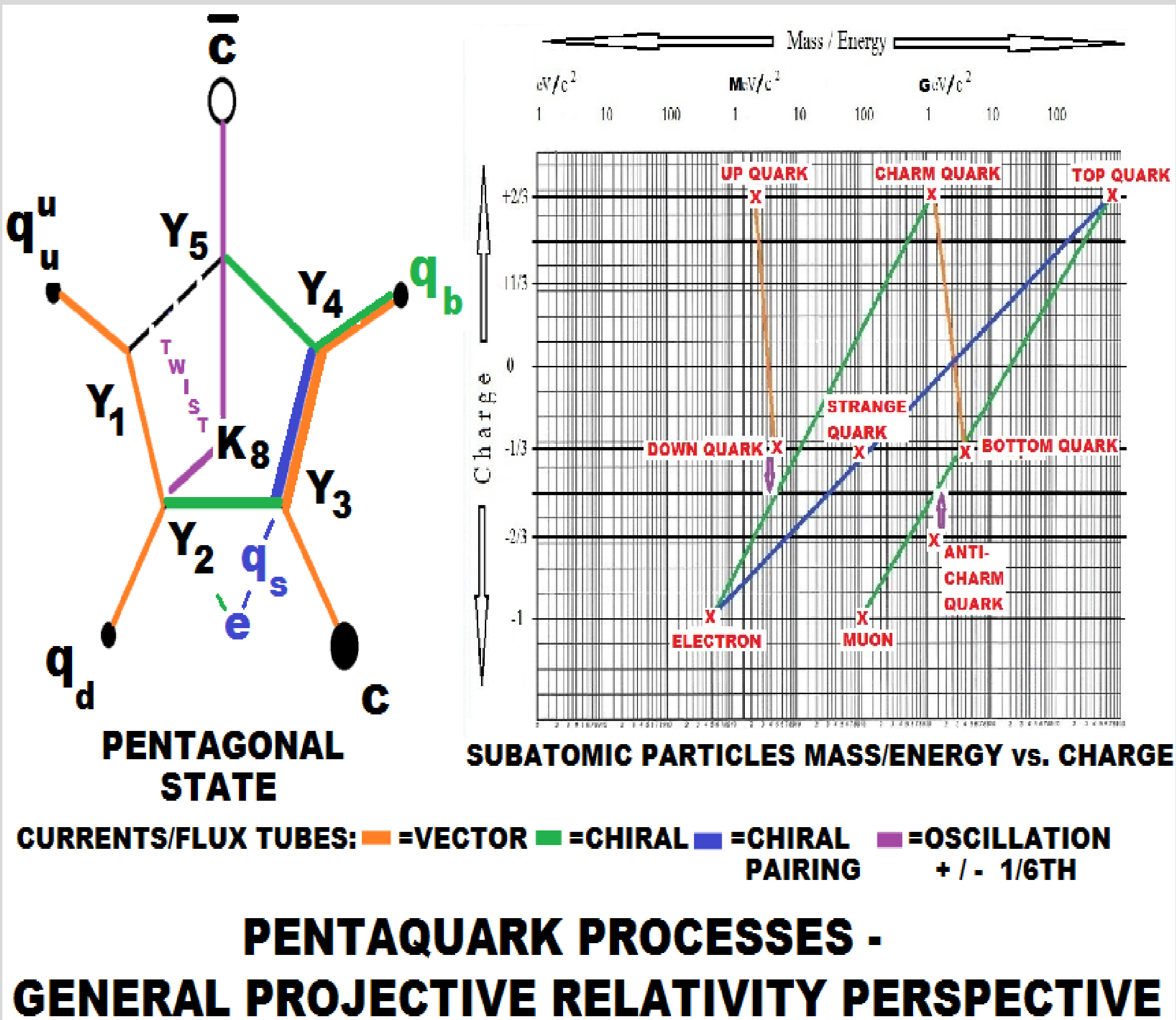
"Therefore geometry is founded in mechanical process, and is nothing but that part of universal mechanics which accurately proposes and demonstrates the art of measuring."

Quote from Isaac Newton's book The Principia

Note that the prior diagram exhibits a networked charge-mass/energy interconnectedness. For example on the right a green line connects the top quark to the muon roughly through the bottom quark. A blue line with less pronounced slope connects the top quark to the electron roughly through the strange quark. A second green line on the left with slope similar to the first green line on the right connects the charm quark to the electron roughly through the down quark. What are these slopes? Quite simply these slopes exhibit a shedding of mass/energy in seeking stable entangled resonant energy states. Using QCD terminology, these semi-log visually and readily apparent lines are flux tubes, also called vector currents (orange lines) and chiral currents (green and blue lines). Notice that the rough connections at charge -1/3 with the bottom, strange, and down quarks exhibit a shifting to the left, thereby representing a progressive shedding of mass in going to the down quark. Interestingly this progressivity ultimately shows up in the up quark at charge +2/3 having a mass that is less than the down quark whereas both the charge +2/3 charm and top quarks have masses greater than their corresponding charge -1/3 strange and bottom quarks. Thus the up quark is representative of a final entangled computational information "crossover / twist" to lowest resonant energy state stability. Diagrammatically all six quarks, in three generations, partake in this progression to crossover lowest resonant energy state stability following pathways that shed mass/energy.

- The strange quark seems to be at the center of everything in the prior semi-log plot, and for good reason. The term “strangeness” was coined to denote particles that were relatively easily created, **in pairs**, but also exhibited a relative long time delay before decaying into more stable subcomponent particles. Pairing and time aspects are indicative of entanglement and computation of information.

- Paper arXiv 1608.03940 Heavy Pentaquark States and a Novel Color Structure (C. Deng, J. Ping, H. Huang, F. Wang) comes at the pentaquark as a QCD isomer, analogous to molecular isomers. In particular paper 1608.03940 discusses a pentagonal state which is color mapped to the prior semi-log plot in the following diagram.



The first aspect to notice about this color mapped pentagonal state is the involvement of the bottom “q_b” and strange “q_s” quarks in the process. The second aspect to notice is that this gives us via the blue chiral pairing flux tube thru the strange quark the electron “e” and second up quark. The third aspect to notice is that there is an oscillatory “Mobius” twist related to the authors’ K8, which is essentially a computation related to the strange quark and projection geometry.

Most notably the “pentaquark” involves the anti-charm quark. If the semi-log mass / energy versus charge diagram exhibits a charge-mass / energy interconnectedness how is the anti-charm quark connected to the “pentaquark”? At first glance there don’t seem to be any “projective” lines for the anti-charm quark that exhibit a pattern of charge-mass / energy interconnectedness. Further scrutiny however shows interconnectedness via the orange lines and purple arrows. The orange lines are of similar slope, one connecting the bottom to the charm quark and the other connecting the down to the up quark. The orange lines represent one type of shedding of mass (i.e. particle decay) which goes up in charge. Since the orange lines have a steep charge slope relative to the green lines they are more quantized reflect oriented. Conversely the green lines represent another type of more progressive shedding of mass (i.e. particle decay) which goes down in charge. Since the green lines have a less steep charge slope relative to the orange lines they are more continuous rotation oriented.

The purple arrows represent on the left at the down quark a drop in charge of -.167 to the green line at -.5 symmetrical on the right at the anti-charm quark to a rise in charge of +.167 to the green line at -.5. **This represents a resonant energy connection which addresses issue “1” concerning the two resonant energy “pentaquark” 4380.0 MeV/c^2 and 4449.8 MeV/c^2 states observed at the LHC. This also represents a super-positional collapse of the Shrodinger wave equation, i.e. an observation of both positional and momentum aspects.**

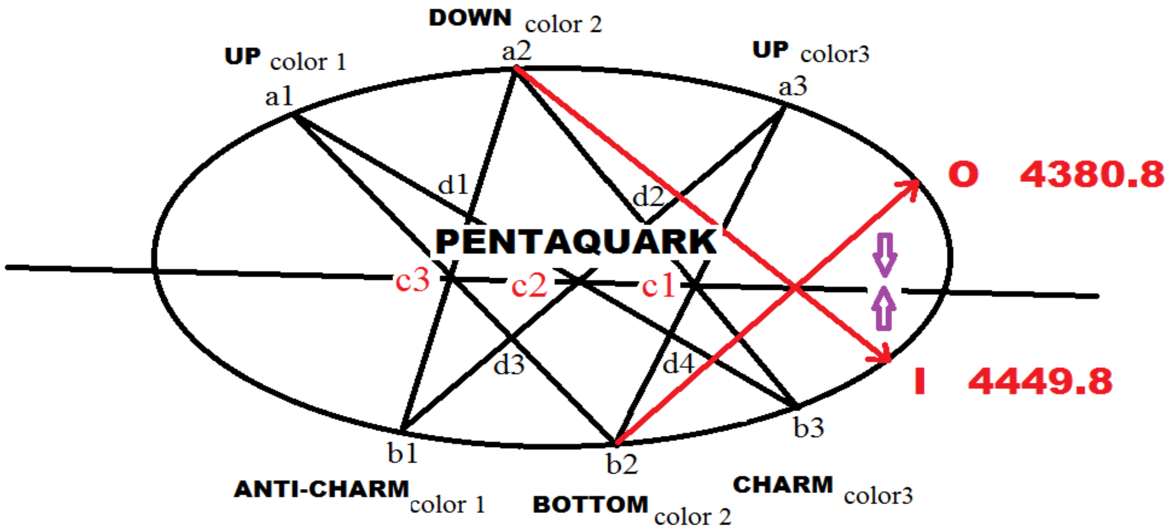
Connection of the anti-charm quark to the “pentaquark” complex then comes in the form of this “charge resonance” plus the green line segment from the anti-charm quark mass up to the bottom quark mass. This makes sense because the bottom quark decays into two main “pentaquark” components, the up and charm quarks. The bottom quark mass / energy is 4180 MeV/c^2 or 4650 MeV/c^2 depending on the mathematical magic used to deal with problem mathematical infinities. The bottom quark is unique in this mass / energy bifurcation. This effectively bounds the 4380.0 MeV/c^2 and 4449.8 MeV/c^2 masses found for the “pentaquark” by the LHC, and quite surprisingly the bounding differential is a nearly symmetrical 200 MeV/c^2 on both sides. This infers the same bottom quark problem mathematical infinities also apply to the “pentaquark”. The (4449.8-4380.0 = 69.8 MeV/c^2) “pentaquark” differential represents .148 of the (4650-4180 = 470MeV/c^2) bottom quark differential. This relates closely to the .167 charge differentials with the difference perhaps representing an entangled binding energy of the resonant energy state “pentaquark” oscillation. This infers the bottom quark is capable hierarchically of quantized resonant energy state oscillations with particle mass bounded by its bifurcated mass range.

Dealing with probability requires observation of both position and momentum. If the “pentaquark” represents a bounded observation of both position and momentum aspects, what might these aspects be? Position infers something that is more certain, i.e. stable. For the “pentaquark” this is the lower mass / energy up-down-up quark baryon part of the “pentaquark” complex. Momentum infers something that is less certain, i.e. less stable. For the “pentaquark” this is the higher mass / energy charm-anti-charm quark meson part of the “pentaquark” complex. **This addresses issue “2” concerning how the “pentaquark” is bound together,** i.e. an entangled binding energy is superimposed on top of baryon and meson component binding energies, and this entangled binding energy is representative of an observation of both position (baryon) and momentum (meson). This entangled binding energy is a property of the interconnected network of particles. In this context position and momentum are super-positional probabilistic state space aspects rather than strictly physical aspects, representing a major change in mindset beyond the physical to the logical.

- The importance of the "pentaquark" having two resonant energy states related to the binding energy of entanglement cannot be overstated. This two state entanglement phenomenon is, of course, also exhibited by electrons and photons in what Einstein termed "spooky action at a distance". The fact that "pentaquarks" share this two state phenomenon implies it is more fundamental and pervasive than warranted by any current theories, and is perhaps even representative of neutron-proton binding energy of entanglement.

  The fact that the green lines are connected at the bottom to the electron and muon infer a connection to the fine structure constant α which is related to strength of electroweak binding (i.e. weak nuclear force WNF and electromagnetic force EMF). The value of the fine structure constant α is only a constant $7.297\ldots x10^{-3}$ at the energy scale of the electron. Starting at the electron, the strength of electroweak binding increases logarithmically with energy scale until it unifies strength-wise with the strong nuclear force SNF. With respect to the "pentaquark" actual binding energy is dependent on this electroweak / SNF relationship, the $1/6^{th}$ charge differential representative of electromagnetic force EMF, and the two resonant energy states which relate to gravitational force G. In this respect the long sought after spin-2 graviton, which would be the basis for a quantum gravity theory, is not a particle in the classic sense, but rather two resonant energy states network entangled in "Mobius" orbit fashion. Thus what the LHC found with the "pentaquark" is the signature of a "gluing" mechanism that does networked interconnections at a level above the gluon. These networked interconnection processes extend Yang Mills force unification to all four forces including gravity. Furthermore all of this is follows from a new overall theory General Projective Relativity (GPR).

This brings us to addressing issue "3" which is why QCD theory is lacking in "affinity" for a "pentaquark" complex containing the relatively more massive and less stable charm quark. Quite simply QCD was developed with a mindset oriented towards that which is strictly physical, which at the quantum level means position and momentum cannot be observed at the same time. In reality beginning at the quantum level probabilistic processes start to entangle both position and momentum. This represents a flow of energy driving progression towards complexity as opposed to entropic randomness. To account for this phenomenon, and address issue "4", a new entangled computational information theory General Projective Relativity (GPR) is proposed. GPR relates to a variety of issues in fields of study including string theory, quantum gravity, dark matter, and dark energy.



GPR PERSPECTIVE - PENTAQUARK

The prior diagram, based on Pascal's projection ellipse, depicts what the "pentaquark" might look like from a GPR perspective. GPR is based on probabilistic "bounding", which has both position and momentum aspects. The top half of the ellipse depicts the up-down-up quark part of the "pentaquark" and is positional bounding of the larger mass down quark representing momentum in the middle. The bottom half of the ellipse depicts the charm-anti-charm quark part of the "pentaquark" and is positional bounding of the larger mass bottom quark representing momentum in the middle. What is projected are the two resonant energy states of the "pentaquark" shown on the right as an Object O and Image I pair, with Object O having the lower more certain mass and Image I having the higher less certain mass. GPR is developed in the context of a new scientific paradigm of networked synthesis.

Acknowledgements:

R. Aaij, LHC_b Collaboration	Phys Rev Lett 115, 072001
C. Deng, J. Ping, H. Huang, F. Wang	arXiv:1608.03940
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