# Cosmic Radiation, Muons and the Need for Quark Structure

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**Abstract**

Up and down quarks are assumed to be elementary (or fundamental) particles although there is no scientific evidence confirming this interpretation. However, there is indirect evidence in the form of the colour change of quarks and the creation of muons by cosmic radiation, and their subsequent decay, that together suggest that quarks are more likely to be composite particles. As well as discussing such indirect evidence, several preon-based approaches that model up/down quarks as composite particles are reviewed.

According to the Standard Model (**SM**), nucleons consist of a triangular array of three up/down quarks held together by strong forces. Up/down quarks are assumed to be **elementary** (or **fundamental**) **particles**, meaning that they do not contain other smaller particles or formations, but there is no scientific evidence confirming this interpretation. However, there is indirect evidence that suggests that they are more likely to contain structure and thus represent **composite particles**.

The first piece of indirect evidence that suggests that, up/down quarks might be composite particles is that, according to **Quantum ChromoDynamics** (**QCD**), they take on varying **colour charge** combinations within nucleons. SM claims that the **strong force** that binds quarks together as nucleons, and holds nucleons together within an atomic nucleus, is due to quarks exchanging **gluons**, with QCD claiming that gluons also carry specific **colour** and **anti-colour** charge combinations between quarks. For instance, a 'blue' quark transforms into a 'red' quark, which has different field-force characteristics, when it emits a cyan (anti-red) and a blue colour charge gluon. The ability to participate in the gluon pass-the-parcel game and dynamically change their colour charge characteristics, suggests that some type of internal structure or organisation exists within up/down quarks which facilitates such interaction.

Another piece of indirect evidence, that is certainly less esoteric and more verifiable than the quark colour charge evidence, relates to the generation of **muons** by **cosmic radiation**. Cosmic radiation contains a mix of high-energy particles and radiation consistent with emissions from the completely ionized hydrogen plasma of distant galaxies. It contains **protons** (89%), **Helium** atoms (10%) and a mix of heavier nuclei (about 1%), as well as abundant levels of high-energy **neutrinos**, **anti-neutrinos** and **gamma radiation**. When cosmic radiation encounters molecules in the Earth's outer atmosphere, muons are created, most likely being generated by the impact breakdown of incoming protons, although it is quite possible that collision-deflected incoming **alpha radiation** (i.e. kinetically energised helium atoms) could also be involved in the muon production process.

Should up/down quarks be considered to be elementary particles, then it might be reasoned that muons are being created by an impact-triggered energy redistribution process causing the magical conversion of a proton, or one or more of its quarks, into elementary particles (i.e. muons and a mix of neutrinos). However, this is a fairly fanciful and is an unlikely scenario. A far more likely and feasible mechanism is that up/down quarks are composite particles, being composed of smaller more elementary particles that are released, albeit slightly modified, as muons by collision impact.

With there being no direct scientific evidence confirming or disproving the elementary particle status of up/down quarks, and the indirect evidence suggesting that they have a substructure, a closer examination of the theoretical models that have suggested a composite structure for up/down quarks is warranted and possibly well overdue. Hence this paper.

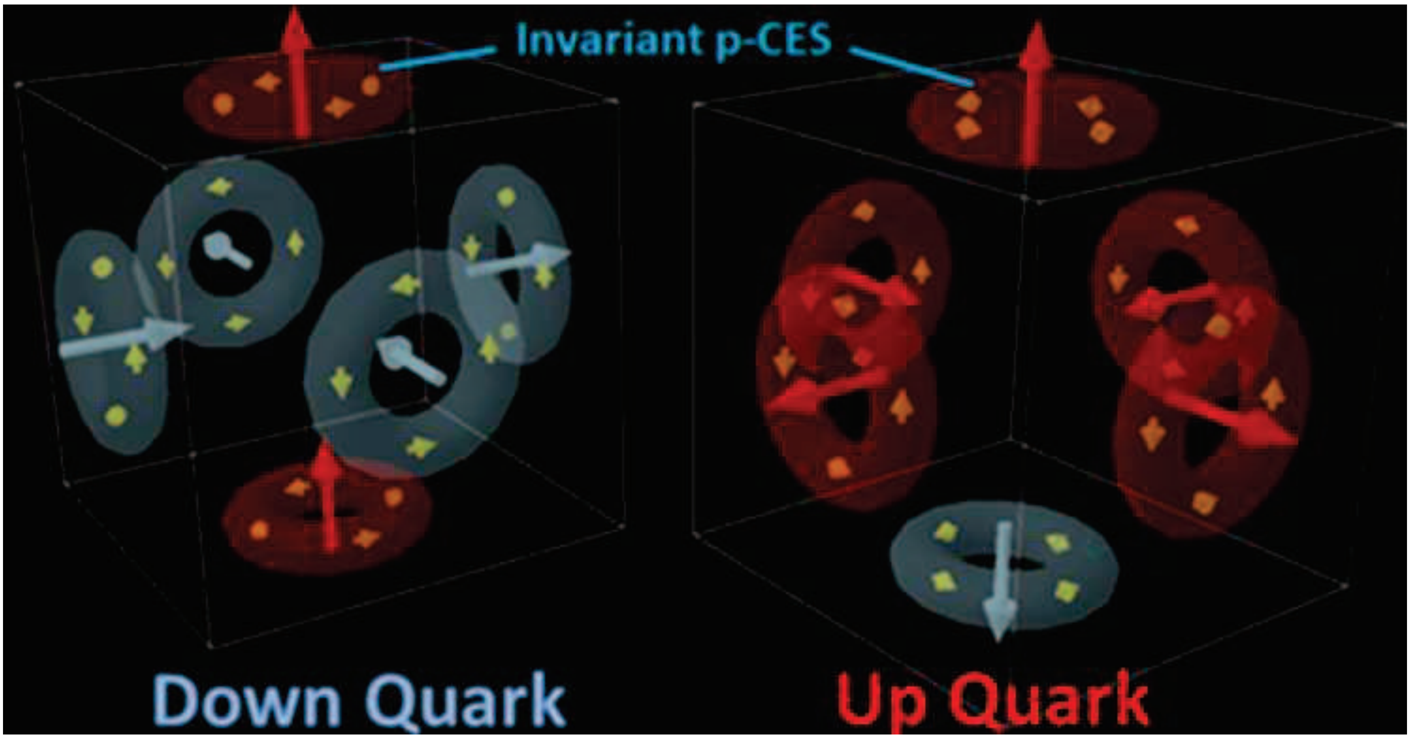
One of the earliest models suggesting a composite structure for up/down quarks was the Rishon (or Harari–Shupe) model**,** first proposed by H Harari 44 years ago in 1979. It suggested a structure applicable to hadrons and fermions involving small elementary particles called **preons** (or **rishons**). The Rishon model defines two types of preon: the Vohu (**V**) and Tohu (**T**), which are both considered to be 1/2 spin elementary particles. Up and down quarks are claimed to consist of three preons each, with **up quarks** having 2*T and 1*V (with patterns TTV, TVT and VTT representing the three colour charges of up quarks) and **down quarks** having 2*V and 1*T (with patterns VVT, VTV and TVV representing the three colour charges of down quarks).

By assuming that the Tohu (T) has a charge equivalent of +1/3 e, that its antiparticle Ť a charge of -1/3 e, and that the Vohu (V) has a zero charge, the net equivalent charge of an up quark (**U**), defined as TTV. TVT or VTT, becomes +2/3 e; and -1/3 e for a down quark (**D**) defined as VVŤ, VŤV or ŤVV. The reason for including a Tohu antiparticle (Ť) within a down quark is rather difficult to justify, and seems to be somewhat contrived so as to arrive at a net charge of +1 e for the proton (**UDU**) and zero for the neutron (**DUD**).

In his 2018 paper '[Quarks, Hadrons, and Emergent Spacetime](#)', P Zenczykowski focusses on estimating rishon mass and charge equivalents , and uses a phase-space based interpretation of rishon to explain baryon spectroscopy. This paper also includes an interesting and balanced discussion of the 'problem of mass', and highlights the differences between the Planck mass scale and hadronic mass scale. It points out the difficulties associated with measuring the mass and charge of up/down quarks, which is quite relevant to the much disputed estimates of their mass.

A more recent preon-based contender to the Rishon model is the **Spin Torus Energy Model** (**STEM**). STEM, last updated in 2023, is predicated upon the hypothesis that there is only one form of **energy-generating material** called **energen**, and contends that all elementary particles have a toroidal form. The STEM version of the preon is called a **Concentrated Energen Source** (**CES**) which, as for the Rishon model's preon, has two forms: the **e-CES** and **p-CES**, each of which is a 1/2 spin particle.

However, whereas the Rishon model considers that up and down quarks consist of 3 rishon, STEM considers them to consist of 6 CES held together by their respective electromagnetic field energy in a **regular octahedron** array (which is equivalent to a **face-centred cubic** form). In the diagram below, the concentrated energen (the **energen core**) of an e-CES is represented by a blue torus and that of a p-CES by a red torus, with the smaller arrows indicating the toroidal flow (or spin) of energen. Also, although **field energy** (which consists of low-concentration energen flow) is not shown, the larger arrows point towards the implied North pole of the magnetic component of their field energy.




Apart from doubling the number of preon per up/down quark, which in itself is a difficult concept to take on board, the STEM quark model offers many advantages. The field energy of e-CES and p-CES are chirally different (e-CES nominally have **left-handed** chirality and p-CES **right-handed** chirality), which accounts for their different electromagnetic characteristics; and, by allocating them a nominal -1/6 e and +1/6 e respectively, the net effective electric charge of a down quark becomes -1/3 e and +2/3 e for an up quark, leading to a net effective charge of +1 e for protons and zero charge for neutrons.

STEM contends that a **muon** (**μ**) consists of a pair of same-type CES resulting from up/down quark disintegration. In terms of contained energen, CES have a nominal rest mass of 52.17 $MeV/c^2$, with a **CES-pair** (i.e. $\mu^-$ = an e-CES pair and $\mu^+$ = a p-CES pair) having a rest mass of 104.3 $MeV/c^2$, which corresponds pretty well to that of an **energised muon** at 105.7 $MeV/c^2$. This would seem to be quite supportive of the proposal that a muon is a same type CES pair.

Also, because each up/down quark within each proton is capable of generating up to 3 muons, and there are 3 quarks per proton, the STEM approach readily explains why so many muons bombard Earth's surface (the estimated average rate is 10,000 particles/ $m^2$/ min at sea level and with an average energy of 3–4 GeV).

Once released from the relative stability of an up or down quark, muons decay rapidly, reducing down to electrons with a half-life of about 2.2 μs. Brief as it is, this decay time still provides many of the fast-moving muons with sufficient time to reach Earth's surface.

STEM suggests that the cause of a muon's instability is that, once it is released from an up or down quark, the strong force attraction between its 2 CES causes their energy cores to come together at speed, which in turn causes them to instantly rebound away from each other in the opposite direction, only to be drawn towards each other again by the strong force attraction, so producing a rapid vibrational effect. This vibrational effect causes energen loss via a combination of multiple short lived (approximately $10^{-5}$ micro seconds) neutrinos, which are generated by field energy compression as the CES come together, and EMR emission (possibly in the ɣ ray frequency range).

The end-products of such a muon decay process would be electrons for $\mu^-$ and positrons for $\mu^+$, which would be the remnants of the CES after energen depletion, and lots of neutrinos and EMR. And with electrons and positrons both being produced via muon decay, a degree of electron-positron annihilation could also be expected in the mix.

Using STEM's nominal rest mass of 52.17 $MeV/c^2$ for a CES, up/down quarks would have an average rest mass of 313 $MeV/c^2$, which is considerably higher than the uncertain and much disputed estimates derived from computer simulations used to interpret Large Hadron Collider data. As a triangular structure consisting of 3 strong-force bonded up/down quarks, the STEM estimate for the average rest mass of nucleons is 939 $MeV/c^2$, which corresponds quite well with the values that have been firmly determined by multiple independent experiments.

Although well beyond the scope of this brief paper, in its discussion paper about Atomic Structure, STEM describes how an e-CES can be readily converted into a p-CES, and vice versa. With one p-CES remaining invariant (as indicated in the quark diagram above), this leads to a simple feasible explanation for the instantaneous conversion of an up quark into a down quark, and thus to an explanation for the **nucleon type conversion** of a proton into a neutron, and vice versa. STEM can also explain how **beta decay** takes place and why **neutrinos** are a by-product of the process. Also, using a nominal CES energy core radius of 2 pm (1 pm = $10^{-12}$ m), which results in a width estimate of 12 pm for up/down quarks in their cubic form (as shown in the quark diagram above), the referenced STEM discussion paper provides detailed true-scale 3D diagrams of many atomic nuclei and associated molecules.

In summary, although the Standard Model considers up/down quarks to be **elementary particles**, there is indirect evidence that suggests they are more likely to be **composite particles** consisting of smaller elementary particles called **preons**. Similarly, **muons**, produced when cosmic radiation impacts molecules within Earth's outer atmosphere, can be considered to be composite particles (e.g. STEM's **CES-pairs**), with the most likely scenario for their production being the impact-based destruction of protons. A composite preon-based model for up/down quarks fits well with the muon creation scenario. As an added bonus, the STEM preon approach leads to a detailed structure for the atomic nucleus and interesting explanations for the beta decay, muon decay and electron capture processes.

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