

Graphic Illustration of Elementary Particles

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Abstract

By presenting a modular graphic system that was developed to represent abstract physical properties and structures of elementary particles, the authors try to reveal another connection between art and science in a way that has not been done before. The building blocks are graphical units designed by the second author. The depictions of some known physical particles are artistic representations of a theory, like the Standard Model of physics. A new modified visualization of rishons (subquark units) is presented and a new hidden property is introduced called *scent* to extend the existing system of physical properties (flavours and colours) and to generate a new theory named *Quantum Scent Dynamics*.

The model of illustration was published partially in [1], and in [2], and a developed detailed model in [3]. In contrast to [3] which *analysed* graphics by the second author, this paper is a *synthetic* attempt to construct particles from the introduced two basic units. The essence of the Quantum Scent Dynamics (QSD) model is that quarks, leptons and bosons are assumed to be composite particles made up of rishons (named after Harari [4]; while other attempts for a composite structure built of less number, but more fundamental particles were proposed in [5], [6], [7], [8], [9] and [10]). The different authors gave different names to the basic units, like preons (prequarks), subquarks, maons, alphons, quinks. We call our units rishons, because with regard to all different properties, nevertheless this model is most similar to Harari's one. This paper is primarily an innovative artistic presentation (this is the reason why it is submitted to the Bridges conference and does not appear in a physics journal; at the same time, the physical content of the QSD model is no less hypothetic than were those in [4]-[10] in the time of their publication.) In contrary to the previous attempts, the QSD model assumes that rishons are distinguished by a property called *scent*. Our rishon can take two, chiral positions in a hypothetic gauge field called the scent field, and these two positions are called *masculine scent* and *feminine scent* in that field. Rishons are assumed to have electric charges $+(5/9)$ for the masculine-scent and $-(4/9)$ for the feminine-scent. (These values differ from those predicted in [4]; cf. [3] for the clue.) Both masculine and feminine scent rishons may appear in three colours. Their anti-particles own complementary colours (cf., [11]), so a rishon-antirishon pair is colourless, alike a triplet of three different colour rishons. The extent of this short paper does not allow to explain the exact meaning of the used properties, and classification of particles, so readers interested in details should turn to [1],[2],[3].

The original QSD model [3] attempted to keep as much features of the Standard Model (SM) as possible. Further developments of illustrating a quasi-standard and a non-standard model are under work. We would like to demonstrate for the Bridges audience, that geometric and artistic graphic visualization may bring close to laymen even the most abstract physical properties of particles. With the help of the coloured basic units and their bounding clips, one can build his/her own favorite elementary particle.

The basic unit of the model is a graphic by T. F. Farkas (Figures 1-2), what can appear in three colours (and their three complementary colours). Note, physical and technical applications use the Red-Green-Blue colour system. That is the mathematically correct way. For illustration purposes, however, the Red-Yellow-Blue colour triplet is aesthetically more appropriate. (Their complementary colours are Cyan-Magenta-Green, cf. in details, [11].) Colours are represented in print by different shades.

One can notice the chirality of the unit (Left-handed in Figure 1 and Right handed in Figure 2) marked by a twist in the centre of each individual graphic.



Figures 1-2: *The L (masculine) rishon and the R (feminine) rishon in a single colour (in Yellow, Red, or Blue).*

Leptons: (Light mass particles are called leptons, like the electrons, positrons, and the so-called neutrinos.) Let's represent the lepton members of the electron generation by red and anti-red (its complementary colour, i.e., cyan) colours.



Figure 3: *The electron (e^-) and the positron (e^+) – (Red-Cyan and Cyan-Red)*

An *electron* (Fig. 3 left) can be composed of a feminine and an anti-masculine scent rishon ($\bar{L}R$). Its charge is -1 [=(-5/9) + (-4/9)]. A *positron* (Fig. 3 right) can be made of a masculine and an anti-feminine scent rishon ($R\bar{L}$). Its charge is +1 [=4/9 + 5/9]



Figure 4: *The neutrino (ν) and the anti-neutrino ($\bar{\nu}$) – (Cyan-Red and Red-Cyan)*

A *neutrino* (Fig. 4 left) can be composed of a feminine and anti-feminine scent rishon pair ($R\bar{R}$). Its charge is 0. Similarly, an *anti-neutrino* (Fig. 8 right) can be made of a masculine and anti-masculine rishon pair ($L\bar{L}$). Its charge is also 0.

This method properly represents the leptons colourless. We propose, that the *muon* and *tau* lepton generations could be represented by the other two colours (yellow and blue) and their complementary colours. For the spin and the bounding clips of the individual rishons, see [3].

Quarks are represented consisting of three rishons. (For explanation: According to the Standard Model of physics three quarks compose the so-called baryons, which include e.g., the proton and the neutron, what

make the everyday matter around us.) Flavour of the quarks is composed by the combination of masculine and feminine rishons. The combinations of the left- and right-twists in a (spin-up) quark are represented in Figure 5. According to the Pauli principle the *LLL* and the *RRR* (the geometrically most symmetric) graphical units (Figure 5) cannot represent real physical particles. There remain two (*LRL* and *RLR*) physically possible graphical units. (Due to the rotational symmetry of the graphical unit, *LRL*, *LLR*, and *RLL* permutations are indistinguishable, i.e., identical.) According to our model, they represent hypothetical, unbound quarks.

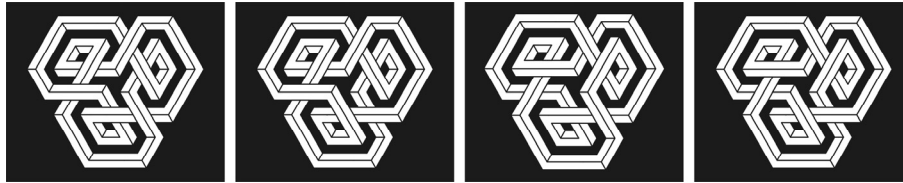


Figure 5: The four possible combinations of Left and Right twists in a graphical unit.

Then we implement in our graphical model the phenomenon that quarks never appear alone, only clipped to others, i.e., in bound states. According to our present knowledge and among natural (not-extreme) physical conditions nature produces only bound quarks. Always three quarks form a *baryon*, and always a quark and an anti-quark form a *meson*. All can appear in three different colours.

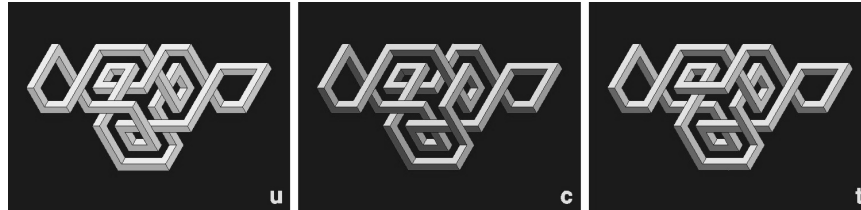


Figure 6: The 3 possible pairs of clips attached to the *LRL* quarks (each represented in one colour only)

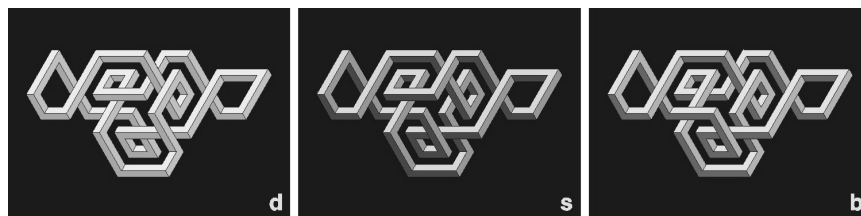


Figure 7: The 3 possible pairs of clips attached to the *RLR* quarks (each represented in one colour only)

Figures 6-7 depict all the six flavour quarks (*u*, *c*, *t*, and *d*, *s*, *b*; each in one colour only) in their bound representation. Please, note the difference in the (chiral) distortion of symmetry in the individual quarks' representation: all the six quarks are represented graphically in a different way! Figure 8 presents the *u* and the *d* quarks in their – hypothetical – unbound state in all the three colours both.



Figure 8: Single quarks in – hypothetical – unbound state.

Left: The *u* (*LRL*) quark in a single colour. Right: The *d* (*RLR*) quark in another single colour.

Baryons (e.g., proton and neutron, and the mesons which mediate interactions between the baryons): We saw above, how can the different flavours be represented in our model by the variation of binding clips to

the individual scents. In this way, we identified the six flavours, that may appear in three colours each. Binding the different flavour quarks to each other in all the possible ways, we can produce the complete family of *baryons*. Figure 9 represents the proton (*udu*) and Figure 10 the neutron (*dud*).

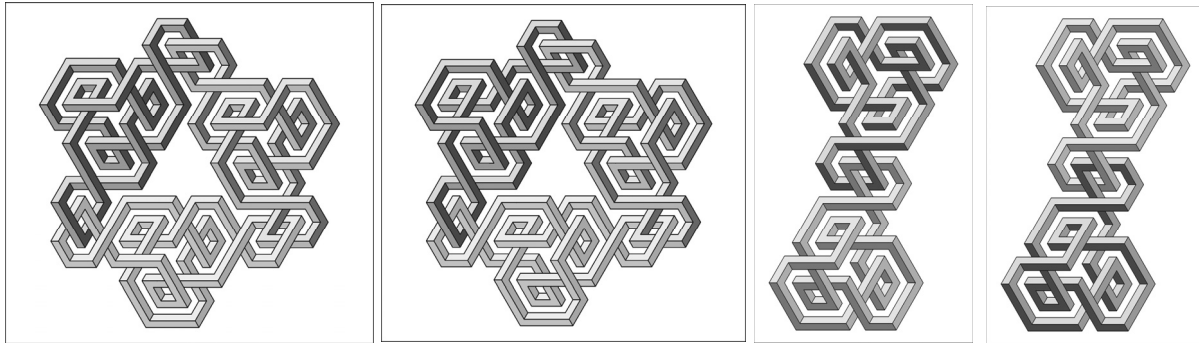


Figure 9: The proton (*udu*). **Figure 10:** The neutron (*dud*). **Figure 11:** π^+ meson. **Figure 12:** π^- meson.

According to the SM of physics, the individual quarks permanently change their colours, so that at any given moment, all of them appear in different colours. This process can be observed on the model of the proton and the neutron in an animated form at the site [1].

Mesons are pairs of a quark and an anti-quark. Anti-quarks – similar to the anti-rishons – are represented in this (QSD) model by their complementary colours. When forming a meson, quarks are bound only to one other, thus – in our model, for symmetry considerations – they join to the anti-quarks next to that scent, which does not take part in binding into a baryon. (E.g., a *u* quark joins to two quarks next to its two *Left-handed* twists, and to an anti-quark next to its *Right-handed* twist.) We can observe an example for modeling two mesons (π^+ and π^-) in Figures 11-12.

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