Why Quarks Aggregate in Threes

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A trio of quarks represents a minimum energy configuration. There are two possible configurations, one positively charged and one uncharged.

We assume the universe is built of discrete Planck units of space-time as first suggested by Bombelli et al. [1] and Requardt [2]. Without loss of generality, we assume that a sphere of radius R will contain 99.9% of a unit's volume.

Second, we assume that the mass of a quark is confined to a single Planck unit, that is, with 99.9% probability it is located somewhere within that unit much as with 99.9% probability an electron is confined to a specific orbital.

Friedgut [3] showed that subject to these assumptions, the surrounding Planck units will decrease in volume in an effort to equalize the energy density. As compressing the surrounding space requires energy, the quarks group themselves so as to minimize the energy required, that is, so as to minimize their effect on the surrounding space.

We show now that an aggregate of three quarks will cause less distortion of the surrounding space than three disparate quarks.

Let E_o denote the ground state energy of a Planck unit, and E the energy equivalent of a quark. Let n_1 denote the number of Planck units an isolated quark comes in contact with. Let r_1 denote the effective radius of each of the units.

$$n_1E_o/r_1^3 = E/R^3 \qquad (1)$$

and

$$n_1r_1 = 2\pi R. \qquad (2)$$

Without loss of generality, define the units of measurement so that E=1 and R=1.

From (1), we see that $r_1 = (n_1/E_o)^{1/3}$ and from (2) that $n_1 = (2\pi)^{3/4}E_o^{1/4}$.

The center of mass of an aggregate of three quarks may be assumed to be at the center of a sphere of radius 2R or 2 in our revised units and to possess energy 3E or 3.

$$n_2E_o/r_2^3 = 3/8 \qquad (3)$$

and

$$n_2r_2 = 4\pi. \qquad (4)$$

So that $r_2 = (8n_2/3E_o)^{1/3}$

and $n_2 = 2^{3/4}\,(3/8)^{1/4}\,(2\pi)^{3/4}\,E_o^{1/4}$

$= 2^{1/2}\,(3/4)^{1/4}\,(2\pi)^{3/4}\,E_o^{1/4}$

$< 3\,(2\pi)^{3/4}\,E_o^{1/4}$

the number of units in direct contact with three isolated quarks.

Our third and last assumption is that the quarks possess an oriented magnetic field. Consequently, any aggregation need be coplanar and can assume one of two possible configurations, one in which the magnetic fields lie within the same plane so as to cancel one another, and one in which they form a single field at right angles to the plane occupied by the quarks.

[1] J. Lee Bombelli, D. Meyer, and R. D. Sorkin, Phys. Rev. Lett. 59, 521 (1987).

[2] J. Requardt, Phys.A 31, 7997 (1998).

[3] P. I. Friedgut, http://statcourse.com/research/Gravity.pdf