Classical Physics without fields and even without space

(Project 2018-6 proposed by Malyshev V.A.)

Space-Time $R^3 \times R$ (or other smooth manifold) for a long time seemed to be inevitable basic frame for classical physics. However, one should accept that it is very rigid and stiff construction. It is evident that space could be only approximation for something more democratic. What can this be ?

1) One of the popular ideas was to use lattices (or discrete graphs) instead of space at very small scales. It is also sufficiently something rigid given apriori.

2) Non-commutative space makes the situation more complicated but does not essentially change it.

3) Another idea could be to refuse completely from space (but not from time, which is assumed to be common for all objects). Assume then that there are N objects $1, 2, \ldots, N$ which we could call particles. Moreover, for any pair $(i, j), i \neq j$, at any time moment t the positive distances $d_{ij}(t) = d_{ji}(\mathrm{t})$ between these elements are defined. These distances evolve in unique time t. but they are not assumed to define metric space, that is the standard inequality does not hold.

4) Even more revolutionary idea is that even there is no common time, but for any pair of particles i, j there is their proper time t_{ij} which is proportional (with coefficient $c > 0$) to d_{ij}. The intervals between communication events depend on this time (or distance). There many problems for such systems. The first one is the following.

Let $N = 2$. The ambitious goal is to find some equations for $d(t) = d_{12}(t)$ and to deduce main two particle interaction laws of classical physics from these equations. There are in fact only two main laws: when velocities are much less than c. the velocity of light, the only interactions are gravity and electrostatics. Both these laws (Newton and Coulomb) have surprisingly the same inverse power form, with different constants defined correspondingly by masses and charges of the two interacting particles. Thus it was very appealing that some derivation of inverse power law, from natural and simple axioms of school level, should exist. The idea is as follows: at times

$$0 < t_1 < t_2 < \ldots < t_n < \ldots$$

where

$$\tau_n = t_{n+1} - t_n = \frac{2d(t_n) + \alpha}{c}$$

the distance d_0 is fixed and there is a recurrent relation

$$d(t_{k+1}) = d(t_k) + \alpha$$

for some real α. This can be interpreted as there is a virtual particle which moves in-between the two objects with constant speed c (analog of velocity of light) ad when it reaches say the particle 1 (the times t_n are exactly these times) the distance changes. Moreover $\alpha = \pm 2\gamma c^{-2}$, where $\gamma > 0$ is some constant (depending on masses or charges of two particles, and the sign depends on the attraction or repulsion inverse square force we want to get. Such virtual particle picture in classical case reminds virtual particles in quantum physics. Moreover, the energy-time relation

$$E\Delta t = \frac{\gamma}{c}$$

follows. It follows from this that $d(t)$ changes as if the Newton law holds with the force equal to $\frac{\gamma}{d^2}$. Locally in time, inverse power law follows just from this. One wants to prove that $d(t)$ behaves on infinite time interval as if between two particles there is inverse power law interaction. It was done in the scaling limit $c \to \infty$ in [1, 2]. Note that only repulsive case was considered.

Further problems

1. Even for $N = 2$ something has to be done. Firstly, to understand what will be in attractive case ($\alpha < 0$). Secondly, if both particles can move.

2. Put both particles to R^2. Let one of the particles stand still at 0. Second particle has initial velocities not parallel to its radius vector. How should we get Kepler orbits in this case ?

3. For $N = 3$ the main question is how these particles could acquire common time and how standard space can emerge.

References

[1] Malyshev V. A. The Newton and Coulomb Laws as Information Transfer by Virtual Particles. Problems of Information Transmission, 2016, v. 62, 3, 308–318.

[2] Malyshev V.A. Models with virtual interaction carriers in classical particle physics. Doklady of Russian Academy of Sciences, 2016, v. 469, No. 3, pp. 291–294.