Look at Bases of Quantum Mechanics

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ABSTRACT: The influence of other interactions on physical objects described by the Dirac and Dirac - Einstein equations has been discussed. Next, the physical meaning of the wave function has been analyzed. This has made me think if a certain law of physics exists which secures the standardization of the phase of wave function which in turn guarantees the non-differentiation of elementary particles of the same kind. In the end there has considered the possibility of the lack of the spectral line broadening in certain physical situations in the correlation to the existence of the negative square of the module of the generalized quaternions.

1.

In the crystal the electromagnetic interactions appear first of all because of the small distances. There is an influence of gravitational and strong interactions and maybe of other interactions which aren't yet discovered.

The Dirac equation has the shape:

$$\left(i\hbar\gamma^{\mu}\delta_{\mu} + V\right)\psi = m\psi$$

The additional interactions enter to the Dirac equation by the potential V (which is the superposition of the potentials of all interactions) and by the mass arising from all interactions too. Moreover, potential and generally wave function may be matrices too. In the case of the wave function the role of the spinor would be acted by its states and eigenvalues.

Next, let's take under consideration the Einstein equation:

$$R_{ik} + g_{ik}\, g^{ik}\, R_{ik} = T_{ik}$$

The additional interactions enter by the tensor T_{ik} , because there are masses connected with each type of interactions.

Moreover, there are higher order corrections connected with the n-pole interactions and n-pole charges and many-body interactions too.
So we have:

$$T'_{ik} \;=\; T_{ik} + \; Q^1_{ik} + \; Q^2_{ik} + \; \ldots$$

Generally:

$$T'_{ik} \;=\; T_{ik} + \sum_n a_n \; Q^n_{ik}$$

Naturally, $div\, T'_{ik} = 0$, what is implicated by the difference of the energy-momentum tensor and too by the fact that if $div\, T'_{ik} \neq 0$ we always could treat the difference as the residual interactions. These interactions are so added to the right member of the Einstein that the divergence disappears.
Generally, the Einstein equation has the shape:

$$R_{ik} + \; g_{ik} \; g^{ik}\, R_{ik} \;=\; T'_{ik}$$

The Lamb interaction with unempty vacuum or the energy of the background radiation may be, for example, these residual interactions.

2. Non-differentiation of particles

We have:

$$\psi \;=\; A\, e^{i\varphi}$$

ψ - a really existing physical field

$$\rho \;=\; \psi^* \psi \;=\; |A|^2$$

and the phase disappears.

Nevertheless, the phase is a really existing physical field too, distinguishing the particles of the same kind.
In purpose to avoid it we must find a certain physical law imposing the marking the phase.
It isn’t known if it isn’t too high price and if such a law can be found.

3. Negative probability

There are the numbers with the negative square of module (some generalized quaternions) which are characterized by the locally negative probability.
We remind:

$$P = \int \psi^* \psi \, dV = 1$$

but locally it may be $\psi^* \psi < 0$.
Moreover, certain generalized quaternions don't fulfill the Heisenberg uncertainty principle because it is implicated by the fact that the square of module is bigger or equal zero [1].
The question arises where we should look for these particles.
The first possibility concerns the tunnels binding the elementary particles with the parallel universes. (The negative probability means that the particles described by it exist in another universe.)
So we must research deeper and deeper structures of the matter.

The second possibility is connected with the search for the objects moving with the velocity comparable with the limit velocity.
In the case of the generalized quaternions describing the velocity there isn't the singularity in the equation: $m = m(v)$

$$m = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

They can cross this barrier without obstacles similarly to the objects described by the objects totally complex $(Re\ x \neq 0)$.
Surely, in certain conditions these objects can emit the radiation whose breadth of spectral line is equal zero with the precision of an experimental error.

Reference:

[1] I. Białynicki-Birula, M. Cieplak, J. Kamiński, „Teoria kwantów, mechanika falowa"