Are we finally walking the Planck?

There has been unease of late that physics is going nowhere. This is partly due to the fact that string theory and its later versions are not delivering anything tangible. Recently, Harry Cliff (Cambridge University and LHC of CERN) articulated these thoughts in the high energy physics community, when he spelt out at a TED Lecture in Geneva, 'the next few years may tell us whether we'll be able to continue to increase our understanding of nature or whether maybe, for the first time in the history of science, we could be facing questions that we cannot answer'. Cliff further says that this situation could be, 'Because the laws of physics forbid it'.

There are two legitimate issues facing us today. Let us first consider the Higgs field. It is believed that this enables particles to pick up mass, and in its absence there would be no mass or matter in the universe. However the energy of the Higgs field should be 'absolutely enormous', which is certainly not observed. In fact it is rather low, being some ten thousand trillion times weaker than its full value.

Then let us consider dark energy and the cosmological constant. This was predicted by the present author[1] in 1997 to be small, imparting a small acceleration to the universe itself. At that time the belief was that the universe was decelerating helped along by dark matter. However, the well-known problem with this small acceleration is, that according to generally accepted ideas, the cosmological constant should be 10^{120} times stronger than the observed value. With such a huge cosmological constant, the universe would instantly blow out after coming into existence, under the repulsive force this imparts. This is the well-known cosmological constant problem as emphasized by Weinberg[2].

Many physicists are coming round to the view that it may not be possible to get answers to these two crucial questions. But the present author has been arguing differently. All the above ideas are based on the Planck scale, some 10^{-33} cm, the smallest scale in the universe. Immediately after the big bang we would have, Wheeler pointed out, the quantum foam. This is a sea of impenetrable Planck-size objects, the smallest possible size in the universe. However the author has been pointing out and demonstrating for the past nearly two decades that the Planck scale quickly undergoes a phase transition which ends up at the Compton scale, which is $\sim 10^{-13}$ cm (cf. for example, refs 3, 4).

This follows from the train of thought that there is a Landau–Ginsburg equation

$$-\frac{\hbar^2}{2m}\nabla^2\psi + \beta|\psi|^2\psi = -\alpha\psi, \qquad (1)$$

which emerges as we can see briefly in greater detail: starting with a simple superposition of states model, first invoked by Feynman, we have

$$\psi(t-\Delta t) - \psi(t+\Delta t) = \sum_j \left[\delta_{ij} - \frac{\iota}{\hbar}H_{ij}(t)\right]\psi(t). \qquad (2)$$

In the limit $\Delta t \to 0$, eq. (2) can be shown to lead to[5]

$$\iota\hbar\frac{\partial\psi}{\partial t} = \frac{-\hbar^2}{2m'}\frac{\partial^2\psi}{\partial x^2} + \int \psi^*(x')\psi(x)\psi(x')U(x')\,\mathrm{d}x'. \qquad (3)$$

This is because, first, the summation over j becomes the integral and, as is well known

$$H(x, x') = \psi^*(x'),$$

or in the Dirac notation

$$H(x, x') = \langle \psi(x') | \psi(x) \rangle,$$

which expresses the probability of a state $|\psi(x)\rangle$ transiting to the state $|\psi(x')\rangle$.

In the above $U(x') = 1$ for x' in a δ-space interval, a small interval around this point, and is zero outside[6,7]. Equation (3) is seen to easily lead to eq. (1) generalizing to 3D.

In the Landau–Ginzburg case, there is a coherence length which is given by

$$\xi = \frac{hv_F}{\Delta}, \qquad (4)$$

which now appears as the Compton wavelength as v_F is c in our case and $\Delta = mc^2$ the energy. From the slightly different analysis of Planck oscillators, we come to the same conclusion[4]. So the picture that emerges is, starting with Wheeler's quantum foam[8], presumably immediately after the big bang, we get eq. (3) and thence are lead to the Compton scale, eq. (4), via eq. (1) and the Landau–Ginzburg mechanism.

This also endows spacetime with a noncommutative geometry that contains the Higgs mechanism[4,9–11]. All this would also bypass divergence issues without the above mentioned difficulty.

This Compton scale gives the answers in complete agreement with experiment and observation, and in fact anticipated them. And physics need not die.

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