Quantum without Quantum

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Science is impossible without variety but may not need wave functions ψ. Particles in space separated by distances $r_{ij} = |\mathbf{r}_i - \mathbf{r}_j|, i, j = 1, \ldots N$, define a minimal model universe. Particles with masses m_i, $\sum_i m_i = 1$, have, respectively, root-mean-square and mean-harmonic lengths

$$\ell_{\mathrm{rms}} := \sqrt{\sum_{i<j} m_i m_j r_{ij}^2}, \quad \ell_{\mathrm{mhl}}^{-1} := \sum_{i<j} \frac{m_i m_j}{r_{ij}}. \tag{1}$$

Their ratio $\ell_{\mathrm{rms}}/\ell_{\mathrm{mhl}} = C$, called the complexity in [1], is the Newton potential made scale-invariant, and a sensitive measure of clustering; if the particles cluster, ℓ_{rms} changes little but ℓ_{mhl} decreases significantly. A long-standing problem in quantum gravity is the definition of time; many believe it should be a variable that describes the universe. In that spirit, C is a candidate. Being positive definite, bounded below by a $C_{\min}$, and unbounded above, C defines a time that begins but never ends. Moreover, the universe is born maximally uniform, becoming thereafter evermore varied. Manuel Izquierdo [2] found typical shapes at birth and soon after for a 1000-particle universe in two dimensions (Figs. 1 and 2). They are critical points of C, and therefore central configurations (CCs) [3], but typical of many shapes with the same C [4].

It is the simplicity of C's definition and the structure of its CCs that leads me to question whether h exists. The CC in Fig. 1, with C at or very near $C_{\min}$, is not new; ones much like it exist in three dimensions [5]. Newton's potential theorem explains their strikingly uniform density within an almost perfect sphere. The 2D rather than 3D calculation explains the slight radial density decrease in Figs. 1–3. The remarkable variety of the voids and filaments in Fig. 2 were a fortuitous discovery of Izquierdo, who, unlike previous researchers, looked for many-particle CCs with C not only very close to $C_{\min}$, but also a bit above it (by $\approx 1.5\%$ in fact).
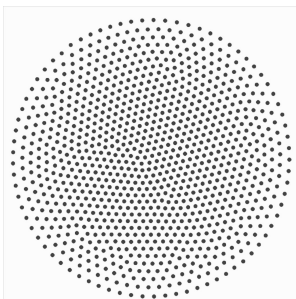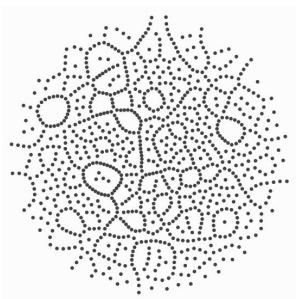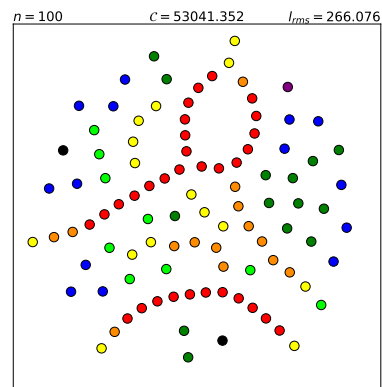

Fig. 1   Fig. 2   Fig. 3

Now for my doubts, expressed briefly due to the nature of this note. The quasi-crystalline structure of Fig. 1 is the first. In fact, BCC crystallisation in CCs of 100,000 particles was found

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in [6]. Crystals, indeed all solids, are seen as quintessential quantum structures explained by wave-function antisymmetry of fermions [7]. I'm not aware anyone has suggested scale-invariant variety by itself can make a wave function ψ redundant, but the simple fact that there are vastly more ways to increase C from its value for Fig. 1 by changing all the r_{ij} slightly than by moving a few closer together explains [4] why the smallest r_{ij} in the filaments of Fig. 2 are very nearly equal. Remarkably, this effect is repeated in other filaments with successively greater separations but with no obvious statistical explanation. Izquierdo's red–orange–yellow coloured sequence of filaments in a typical 100-particle CC in Fig. 3 highlights the effect; it would be even more striking without the r_{ij}-increasing 2D edge effect. Is it fanciful to see in Figs. 2 and 3 protein chains in protozoic cells? If work in hand shows that, in all such CCs, the separations go up in steps that to a good accuracy are the same, that would cast more doubt on the need for wave functions. The paramount condition for that is met: correlations of arbitrarily long range exist everywhere in profusion. There are $\approx N$ of them between the $N(N-1)/2$ separations r_{ij}, which just $3N-6$ coordinates determine. Figure 2 is redolent of quantum-like probabilities; for example, given as a Bayesian prior that a closed loop of x links exists somewhere, how many particles can one expect to find within it? It is the correlations between a source, two slits, and the pattern of fringes on an emulsion that are so hard to explain without interfering ψ branches. The same is true of the Bell inequalities, now confirmed over seemingly arbitrary distances. Figures 1–3 suggest that the holistic nature of shapes with given C, whether CCs or not, may allow a top-down explanation of facts that baffle in a reductionist, bottom-up approach. In this connection, consider the actual evidence for quantum mechanics. In the early days it was mostly in photographs taken in laboratories. Indeed, what might be called generalised photographs—records encoded in distributions of matter—remain the sole source of evidence for wave functions. Examples are the huge detectors at the LHC. But they and it are the tiniest part of the universe. Were the theoreticians who invoked wave functions 'looking in the wrong direction'. Did they need, but could not get, a snapshot of the whole universe containing within it the laboratory photographs? Suppose a dime, representing the region captured in such a photograph, is placed anywhere on the images in Figs. 2 or 3. The single condition that C be critical fully explains the highly correlated structure the dime covers. There is no need for any ψ. Lack of space precludes further discussion here, but as Tim Koslowski said, if there is no wave function, that at least solves the measurement problem of how it collapses.

References.

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