The role of statistics in quantum scale observation explains microscale behaviour

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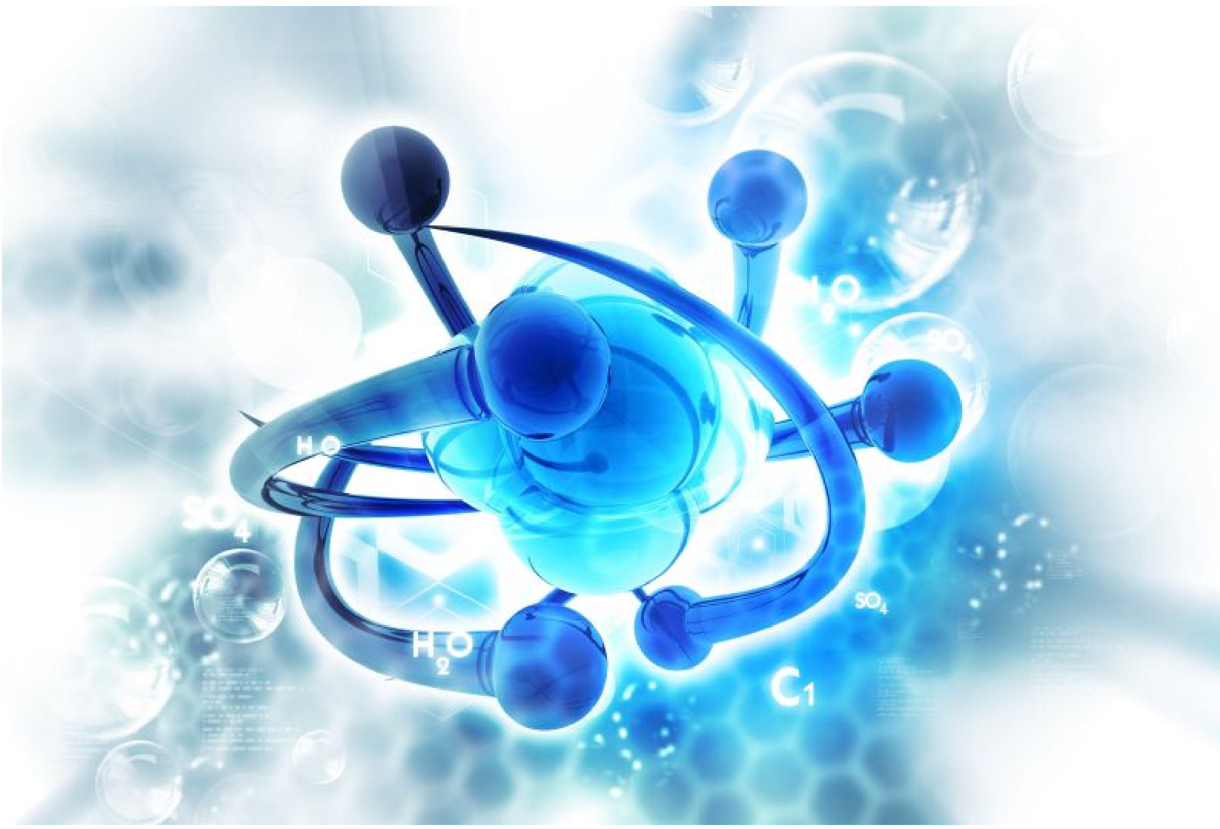

The laws of physics governing the macro scale appear to be an approximation of what is happening at the quantum scale. Credit: hywards / Fotolia

There is a gap in the theory explaining what is happening at the macroscopic scale, in the realm of our everyday lives, and at the quantum level, at microscopic scale. In this paper published in *EPJ D* , Holger Hofmann from the Graduate School of Advanced Sciences of Matter at Hiroshima University, Japan, reveals that the assumption that quantum particles move because they follow a precise trajectory over time has to be called into question. Instead, he claims that the notion of trajectory is a dogmatic bias inherited from our interpretation of everyday experience at the macroscopic scale. The paper shows that trajectories only emerge at the macroscopic limit, as we can neglect the complex statistics of quantum correlations in cases of low precision.

The simple reason why it is wrong to assume that microscopic trajectories exist is because, in quantum mechanics, we can only approximately determine position and speed. This is due to a law of quantum physics, called the Heisenberg uncertainty principle, which prevents the experimental observation of trajectories and other continuous changes in time.

Hofmann shows that this uncertainty of time evolution is a result of the fundamental laws of motion. At the macroscopic limit, motion is described by a change in time along a trajectory of fixed energy. This relation between energy and time can be represented by an action. And this action is the origin of the mysterious effects of quantum coherent superimpositions and quantum interferences. The paper clarifies the role of actions by deriving equations for them that work equally well for quantum dynamics and for classical trajectories.

The paper thus explains for the first time why Planck's fundamental constant (h-bar or ħ) can be used to objectively separate and distinguish macroscopic experience from microscopic physics. Indeed, h-bar identifies a fundamental scale at which the approximate separation of a motion from the interactions needed to observe that motion breaks down. Planck's fundamental constant therefore identifies a fundamental scale where there is an effective cross-over from observable realities to quantum mechanical laws of causality, where the action appears as a quantum phase (i.e one of the many alternative phases for a quantum scale system).

More information: Holger F. Hofmann. On the fundamental role of dynamics in quantum physics, *The European Physical Journal D* (2016). DOI: 10.1140/epjd/e2016-70086-8

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