the general science journal

How Mathematics and Physics Look at the Sum of 1 plus 1
or
Is de Broglie's Theory Applicable to Macroscopic Objects?

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Back in elementary school or often in our parents' home much earlier, we were taught that 1 plus 1 equals 2. No one doubts that elementary mathematical statement. However, from a physicist's point of view, that claim is doubtful. Indeed, in his opinion, in the macroscopic world, 1 + 1 is not 2. One sand grain cannot be simply added to another because they are different. The same can be said for volcanic ash particles, volcanic bombs, asteroids, comets, planets (and their moons), stars and galaxies (hereinafter macroscopic objects).[1]

Let us consider the microscopic world. The simplest atom is the hydrogen atom H. Two of these atoms are identical.[2] The same can be said for two protons or two neutrons and all other microscopic objects. The simplest molecule is the hydrogen molecule. Two of these molecules are also identical. Thus, in contrast to macroscopic objects, microscopic objects can be added to each other. In other words, the microscopic world and elementary mathematics are even in agreement on the elementary level. In our opinion, the macroscopic and microscopic worlds are so distinct that their reconciliation is pointless.

The foundation for modern quantum physics is de Broglie's theory. This theory states that all matter has a wave-like nature and can be described through his mathematical equation:

$$\lambda = h/mv \quad \ldots (1)$$

where h (= 6.63×10^{-34}J sec) is Planck's constant, m and υ is the mass and speed of the object. According to this equation, the Broglie's theory is even applicable to the moving microscopic particles as well to the moving macroscopic objects.

Heisenberg's Uncertainty Principle is a fundamental principle of quantum physics. It states that it is impossible to know exactly both the position and the momentum of a particle simultaneously. This principle can be only applied to the microscopic particles and arises from

[1] We excluded living organisms from macroscopic objects because they are fundamentally different from non-living physical systems.

[2] Hydrogen atoms could appear they be similar because our ability to observe them in detail is rather limited. The same can be said for electrons, protons, neutrons and other microscopic particles.

their wave-matter duality. The origin of the uncertainty principle is found in the duality of particles in quantum physics.

Quantum physics states a microscopic particle can be in two places at once. As far as we are aware, this was experimentally demonstrated for the electron but also some complex giant molecules. One can extend this conclusion to the macroscopic objects. Indeed, if a galaxy or a group of galaxies can also occupy two places at once then we have two universes at once.

Quantum entanglement is a quantum physical phenomenon that occurs when the microscopic particles photons, electrons, atoms, or molecules interact quantum-mechanically even when they are separated by large distances in space. Of course, the macroscopic objects as listed above cannot interact quantum-mechanically.

New experiments from two separate teams of researchers [1, 2] reported observing quantum entanglement between two aluminum membranes ("drums"), of about 10 micrometers in size. They managed to simultaneously measure the position and the momentum of the two drums. This is possible since, as we stated above, the Heisenberg uncertainty principle is valid only for microscopic particles but not for macroscopic objects. It appears that the size of these drums is about the upper limit of the microscopic particles and the lower limit of the macroscopic world.

The question now arises as to whether or not there is a sharp boundary between the microscopic and the macroscopic objects? The answer to that question is expected from physicists.

If the three-above quantum "oddities" cannot be applied to macroscopic objects then the question arises: why would de Broglie's theory, as one of the basic theories of quantum physics, be applicable to these objects? We reason that this theory and its equation (1) are not applicable to the macroscopic objects but only to the microscopic particles.

References

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[2] Laure Mercier de Lépinay, Caspar F. Ockeloen-Korppi, Matthew J. Woolley, and Mika A. Sillanpää, *Quantum mechanics–free subsystem with mechanical oscillators.* Science, 372, 625-629 (2021).