The Classic Paradoxes of Quantum Theory

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This paper contains four new dialogues among Simplicio, Salviati, and Sagredo, on the fate of Schrödinger's cat, the existence of physical quantities, the paradigm of Einstein, Podolsky, and Rosen, and why a watched kettle may boil, after all.

1. SCHRÖDINGER'S IMMORTAL CAT

Simplicio. Who did this dastard act to shabby
On some poor and cuddly tabby?
Was it a wave, was it a thing
That was behind the lethal sting?\(^{(1)}\)

Salviati. ...?

Simplicio. Who killed Schrödinger's cat?

Salviati. I see! You have learnt quantum mechanics.

Simplicio. Yes indeed, and I am absolutely appalled by the heinous experiment which Professor Schrödinger performed on his cat. To demonstrate that his new wave mechanics applies to everything, even to cats, Professor Schrödinger locked his pet in a box, together with a radioactive atom and an automatic device which releases a lethal gas when the atom decays. Thus, after one half-life of the atom, the Schrödinger wavefunction became

\[
|\psi\rangle = 2^{-1/2}(|L, u\rangle + |D, d\rangle),
\]

\(^{(1)}\) Dedicated to Nathan Rosen, teacher and friend, on the occasion of his 75th birthday.
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where $|L, u\rangle$ refers to a living cat (with an undecayed atom) and $|D, d\rangle$ to a dead cat (with a decayed atom). This is horrible! The poor cat was left hovering between life and death.

_Salviati._ Let me reassure you. The distinguished Herr Professor is only a theorist and performed what he calls “eine Gedankenexperiment.” There is nothing cruel or unusual in Eq. (1).

_Simplicio._ But what is the meaning of this wavefunction? Is the cat alive or dead?

_Salviati._ These are two different questions and I’ll answer them separately. The meaning of the wavefunction in Eq. (1) is precisely what you told us: a living cat was locked in a box together with a radioactive atom and a device which kills the cat if and when the atom decays. After waiting one atomic half-life, you get Eq. (1). The wavefunction is not a property of the cat. It represents only an experimental procedure.\(^\text{(2)}\)

Now, to know whether the cat is alive or dead, you must open the box. This is a new experimental procedure. If you perform it, then you get a new wavefunction, either $|L, u\rangle$ or $|D, d\rangle$.

_Simplicio._ That is clear, but what is really the state of the cat just before we open the box? Objectively, it ought to be alive or dead, even if we don’t know the answer yet.

_Salviati._ This question cannot be answered by quantum mechanics.

_Sagredo._ There is no such thing as “objectivity” in quantum theory.

_Salviati._ I wonder whether our venerated teacher Galileo\(^\text{(3)}\) would have accepted this statement. As you know, Einstein was not happy with this state of affairs and claimed that the quantum mechanical wavefunction does not give a complete description of physical reality.\(^\text{(4)}\)

_Sagredo._ Anyway, you have not yet answered Simplicio’s question: What happened to the cat before one opens the box? To answer it, we shall modify the Gedankenexperiment. Suppose that I’ll enclose you, Salviati, in the box with the cat and the rest of the equipment (with adequate protection from the toxic gases, of course). Then, in Eq. (1), the symbol $|L, u\rangle$ will represent a living cat, an undecayed atom, and our friend Salviati aware that all is well; and the symbol $|D, d\rangle$ will stand for a dead cat, a decayed atom, and Salviati sorry for them.

_Salviati._ Do you mean that I shall come out from your experiment suffering from schizophrenia?