Basic interpretations of quantum mechanics

Say for this state, a measurement of the position of the particle is made, and it is found “at” (to within measurement uncertainty) position c. Three historical interpretations:

1) Realist (Einstein): It was at c just before the measurement. ⇒ Quantum mechanics is an incomplete theory, because there was a definite position before the measurement, but quantum mechanics was unable to tell us what it was. This is called a “hidden variable” theory, because there is some property of the particle which could tell us the position before the measurement.

1964: John Bell proved that local hidden variable theory (meaning the variable is spatially fixed to the particle) is wrong!!

2) Copenhagen Interpretation (Bohr): The particle did not have a defined position before the measurement. The measurement itself changed it into a state with a well-defined position. (This is the orthodox view.)

3) Agnostic. It makes no sense to speculate about the reality before the measurement. Theory need only predict the result of the measurement (at least the probability for each possible result).

Probability current

\[ \frac{d}{dt} \int_a^b \left| \psi(x) \right|^2 dx = \text{rate of change in total probability for the region } a \rightarrow b \]

Where the probability current

\[ j_x(x,t) = \frac{i}{2m} \left( \psi^* \frac{\partial \psi}{\partial x} - \psi \frac{\partial \psi^*}{\partial x} \right) \]

Arbitrary oscillation frequency

\[ E = \frac{p^2}{2m} + V = \hbar \omega \]

\( \varepsilon \) can choose zero for PE ⇒ can choose value of \( \omega \)

As we'll see, its only differences in \( \varepsilon \) that matter.

This means that the value of \( V_p = \frac{\omega}{k} = \frac{2\pi v}{k} \) is arbitrary!!

Wave Packets + group velocity

To discuss velocity meaningfully, need a localized particle, e.g.

Particle is definitely somewhere in the range \( d \).

SEQ is linear ⇒ can create such a \( \psi \) by superposing plane waves.