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Real Pictures of Quantum Processes

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At the Commemoration for 100th anniversary of quantum mechanics
The two Nobel winner had a heated argument:

Zeilinger A.: "There is no quantum world. Quantum states exist only in head. They describe information, rather than reality"

Aspect A.: "I disagree !" --

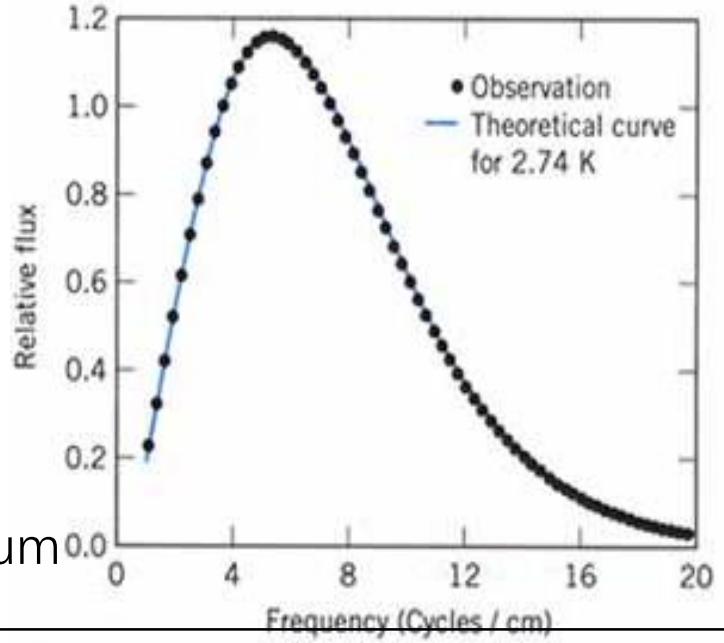
Nature survey over 1,000 physicists

on whether wavefunction represents something real"

36% something real
47% simply a useful tool
8% subjective beliefs about experimental outcomes

Quantization of Expanding Cosmic Vacuum

The total energy of photons or other luminous matter particles does not exceed 5% of the total energy of the expanding universe: photon cannot be the quantum of expanding cosmic vacuum.



COBE spectrum

The absolute blackbody spectrum of the Cosmic Microwave Background indicates that the quanta of the cosmic vacuum medium can only be thermal phonons, or quasi-photons with Planck energy distribution.

The extremely precise Planck spectrum of CMB indicates: quanta of expanding vacuum **should** be collective thermal quasi-photons without mechanical momentum, not free photons

Two Coexisting Neutral Cosmic Vacuums

Vacuum	Quantization
Global Static Zero-Temperature	Particle pair generation
Local Expanding Universes	Quasi-photons γ^*
	γ^*- e coupling $\alpha^* < \alpha$

Quantum Wavepacket of Free Electron

➢ From Maxwell Equations

$$\begin{aligned}
\nabla \cdot \boldsymbol{E} &= 0 \\
\nabla \cdot \boldsymbol{H} &= 0 \\
\nabla \times \boldsymbol{E} &= -\frac{\partial \boldsymbol{B}}{\partial t} \\
\nabla \times \boldsymbol{H} &= \frac{\partial \boldsymbol{D}}{\partial t}
\end{aligned}$$

$\rho = 0 \quad \boldsymbol{j} = 0$

$$\begin{aligned}
\nabla \cdot \boldsymbol{E} &= \rho/\epsilon_0 && \text{Coulomb's law} \\
\nabla \cdot \boldsymbol{H} &= 0 && \text{Gauss's law} \\
\nabla \times \boldsymbol{E} &= -\frac{\partial \boldsymbol{B}}{\partial t} && \text{Faraday's law} \\
\nabla \times \boldsymbol{H} &= \boldsymbol{j} + \frac{\partial \boldsymbol{D}}{\partial t} && \text{Maxwell-Amper's law}
\end{aligned}$$

EM Wave

Maxwell Equations

vibration traveling in vacuum

only transverse fields

composed of quasi-photons with $\in = \hbar\omega \; and \; p = 0$

Quantum Wavepacket of Free Particle

➢ From Schrodinger Equation

Stationary Schrodinger equation $$-\frac{\hbar^2}{2m}\nabla^2\psi = [E - U(\boldsymbol{x})]\psi$$

Schrodinger equation of free particle $$-\frac{\hbar^2}{2m}\nabla^2\psi = E\psi \qquad k = \sqrt{2mE}/\hbar$$

Wavefunction of free particle $$\psi(x,t) = A\exp\left[\mathrm{i}\hbar(x - \frac{\hbar k}{2m}t)\right] + B\exp\left[-\mathrm{i}\hbar(x + \frac{\hbar k}{2m}t)\right]$$

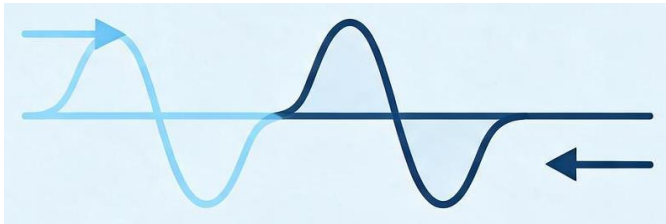
plane wave  $p = \hbar k$

plane wave = retarded wave + advanced wave

only longitudinal fields

composed of free photons with $\in = \hbar\omega \; and \; p = \hbar k$

Non-relativity: advanced wave violates causality

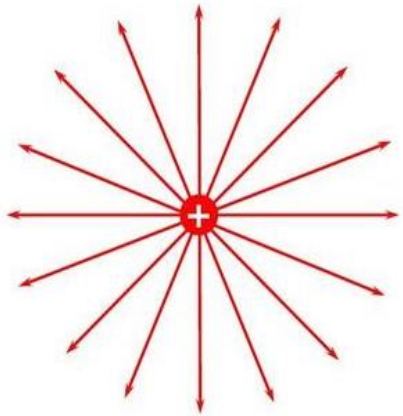


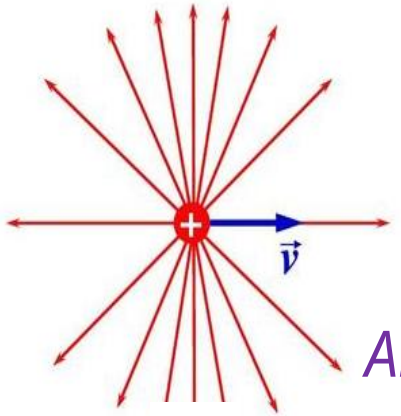
Quantum Wavepacket of Free Electron

➢ **From Retarded Potentials**

$\emptyset$ A

$Coulomb\ field$ $\boldsymbol{E}_{\mathrm{L}}$ $\boldsymbol{H}$ $\boldsymbol{E}_{\mathrm{T}}$ $\boldsymbol{H}$ & $\boldsymbol{E}_{\mathrm{T}}$

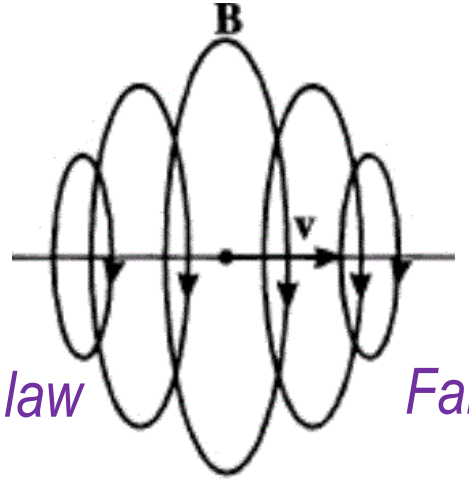




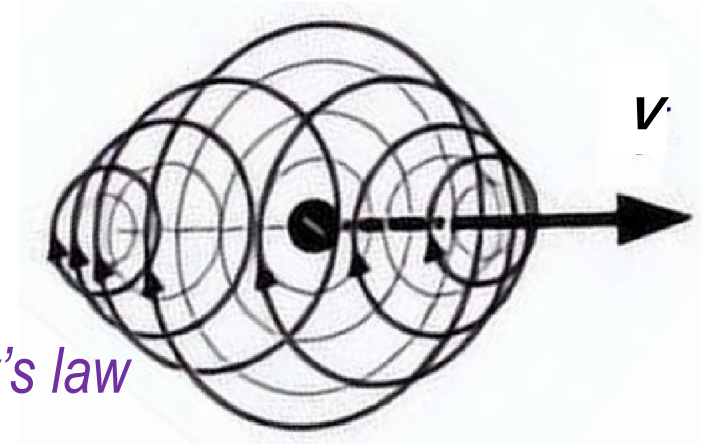
m_0 m_0

Plane waves

$\frac{\partial \boldsymbol{E}_{\mathrm{L}}}{\partial t}$ Ampere's law



$\frac{\partial \boldsymbol{H}}{\partial t}$ Faraday's law



$m_T = (\gamma - 1)\, m_0$

Quasi-photons

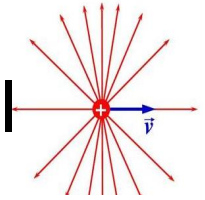
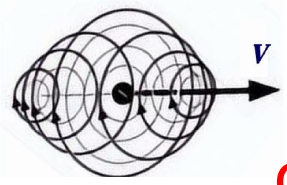
Free electron's wavepacket consists of two mutually perpendicular components: longitudinal field $\boldsymbol{E}_{\mathrm{L}}$ and transverse field $\boldsymbol{H}$ & $\boldsymbol{E}_{\mathrm{T}}$

The 4/3 Problem in Electromagnetism

For a moving particle of proper mass m_0, its observed mass $m = \gamma m_0$
but from Maxwell equations $m = 4/3\ \gamma m_0$

This serious trouble has been persisted over 120 years.

Electric field and magnetic field (E, H) are basic variables in Maxwell equations, but $\boldsymbol{E} = \boldsymbol{E}_{\mathrm{L}} + \boldsymbol{E}_{\mathrm{T}}$ is a mixture of two mutually perpendicular fields, and transverse field $\boldsymbol{H}$ is missing $\boldsymbol{E}_{\mathrm{T}}$. In quantum theory basic variables should be the mutually perpendicular fields $(\boldsymbol{E}_{\mathrm{L}}, \boldsymbol{H} \& \boldsymbol{E}_{\mathrm{T}})$

Real free electron = Longitudinal  + Transverse 

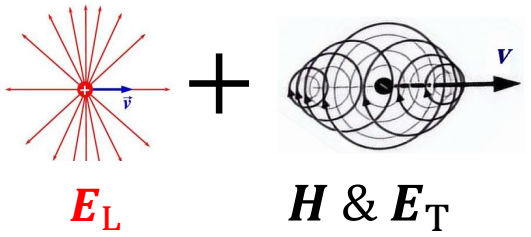
$\boldsymbol{E}_{\mathrm{L}}$ $\boldsymbol{H}$ & $\boldsymbol{E}_{\mathrm{T}}$

quasi-particles:
$\in = \hbar\omega\ \boldsymbol{p} = \boldsymbol{0}$

$$m = m_{\mathrm{L}} + m_T = m_0 + (\gamma - 1)m_0 = \gamma m_0$$

Physical Meaning of Wavefunction

A free particle consists of two perpendicular fields:
Its strength distribution should be a complex quantity



$$\psi(\boldsymbol{x},t) = \mathrm{i}\,\psi_L(\boldsymbol{x},t) + \psi_T(\boldsymbol{x},t)$$

$$\psi_L(\boldsymbol{x},t) = \sqrt{\omega_L(\boldsymbol{x},t)/m} \qquad \psi_T(\boldsymbol{x},t) = \sqrt{\omega_T(\boldsymbol{x},t)/m}$$

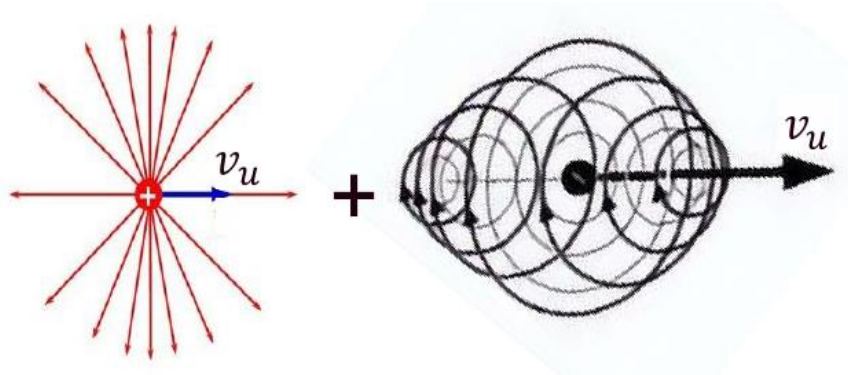
with ω_L and ω_T being the energy density of the longitudinal field E_L and transverse field $\boldsymbol{H}\&\boldsymbol{E}_\mathrm{T}$, the probability density of a free charge appearing at ($\boldsymbol{x}$, t) is

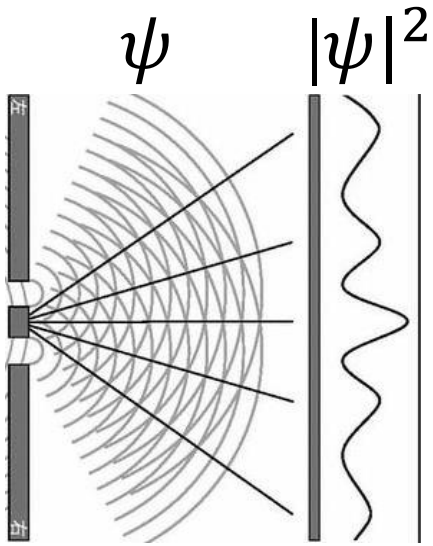
$$|\psi(\boldsymbol{x},t)|^2 = \psi_L^2 + \psi_T^2 = [\omega_L(\boldsymbol{x},t) + \omega_T(\boldsymbol{x},t)]/m$$

Which satisfy the conservation law of energy
and the probability normalization condition

Diffraction, Cohenrence and Linear Superposition

$$\psi(\boldsymbol{x},t) = \mathrm{i}\,\psi_L(\boldsymbol{x},t) + \psi_T(\boldsymbol{x},t)$$





What produces diffraction and coherence is the real traveling wave described by the wavefunction $\psi(\boldsymbol{x},t)$

particle wave is real traveling wave not pilot wave guiding particle moving

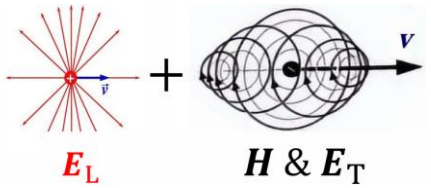
it is also the reason of the linear superposition property of quantum states

Schrodinger Equation

For Free Electron $\mathrm{i}\hbar\dfrac{\partial\psi(\boldsymbol{x},t)}{\partial t}=-\dfrac{\hbar^2}{2m}\nabla^2\psi(\boldsymbol{x},t)$

$$\psi_L(\boldsymbol{x},t)=A\exp[-\frac{1}{\hbar}(Et-\boldsymbol{p}\cdot\boldsymbol{x})]$$

Plane Wave with infinite phase velocity

Real wavepacket 

Retarted Longitudinal Wave + Transverse Weve with Quasi-Photons of P=0

For Bound Electron with spherically symmetric potential U

$$\mathrm{i}\hbar\frac{\partial\psi(\boldsymbol{x},t)}{\partial t}=-\frac{\hbar^2}{2m}\nabla^2\psi(\boldsymbol{x},t)+U(\boldsymbol{x})\,\psi(\boldsymbol{x},t)$$



$$\psi(\boldsymbol{x},t)=\mathrm{i}\,\psi_L(\boldsymbol{x},t)+\psi_T(\boldsymbol{x},t)$$

orbital longitudinal wave + transverse wave with quasi-photons

Relativistic and Non-Relativistic

$$\psi_L(\boldsymbol{x},t) = A\exp[-\frac{1}{\hbar}(Et-\boldsymbol{p}\cdot\boldsymbol{x})] \quad \Leftarrow \quad \mathrm{i}\hbar\frac{\partial\psi(\boldsymbol{x},t)}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\psi(\boldsymbol{x},t)$$

ψ_L: Non-Relativistiv Plane Wave with infinite phase velocity

$$\psi(\boldsymbol{x},t) = \mathrm{i}\,\psi_L(\boldsymbol{x},t) + \psi_T(\boldsymbol{x},t) \quad \Leftarrow \quad \mathrm{i}\hbar\frac{\partial\psi(\boldsymbol{x},t)}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\psi(\boldsymbol{x},t) + U(\boldsymbol{x})\,\psi(\boldsymbol{x},t)$$

ψ_T: Transverse Wave with quasi−photons

Transverse field composed of vacuum quasi-photons only has inertial mass and no mechanical momentum, resulting in relativistic effects − the constant speed of light, time dilation and length contraction.

Why non-relativistic Schrodinger equation works well, but relativistic Klein-Gordon equation fails ?

Special relativity effect is quasi-particle effect of transverse waves not space-time effect

Instantaneous Propagation Paradox in Quantum Physics

Wavepacket Collapsing

Electron mass m_e radius r_e from uncertainty relation $r_e\, p_e \sim \hbar$

$$V_{collapse} \sim \hbar / r_e m_e \sim 10^4\, c$$

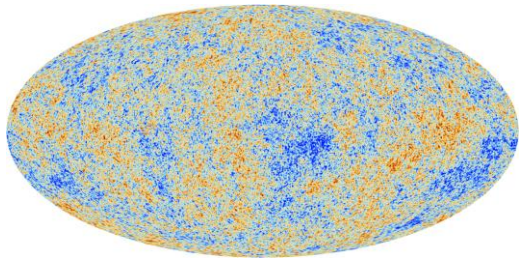
EPR Paradox

Measurement result of quantum entanglement

$$V_{entanglement} > 10^4\ \mathrm{c}$$

Cosmic Expansion Velocity

$$V_u \approx 4 \times 10^4 c$$

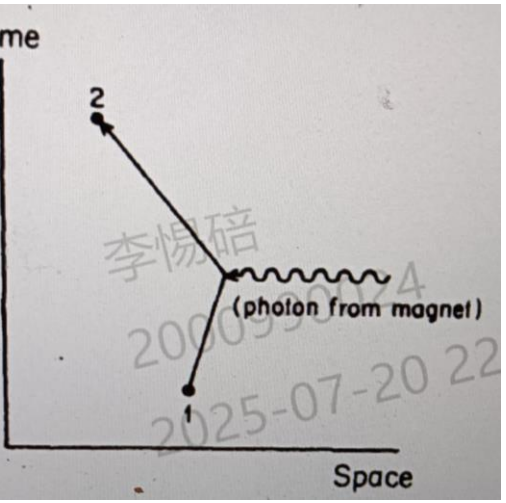


The phase velocity of local expanding vacuum medium is C. It is likely that the phase velocity of global high-density vacuum medium, although high, but still limited

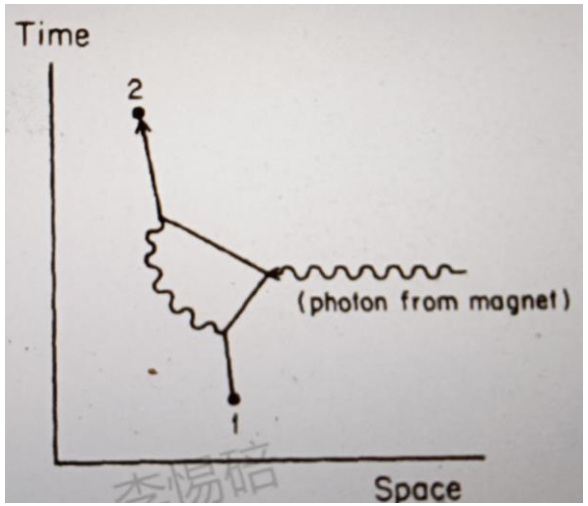
$$V > 10^4\ \mathrm{c}$$

Electron Magnetic Moment

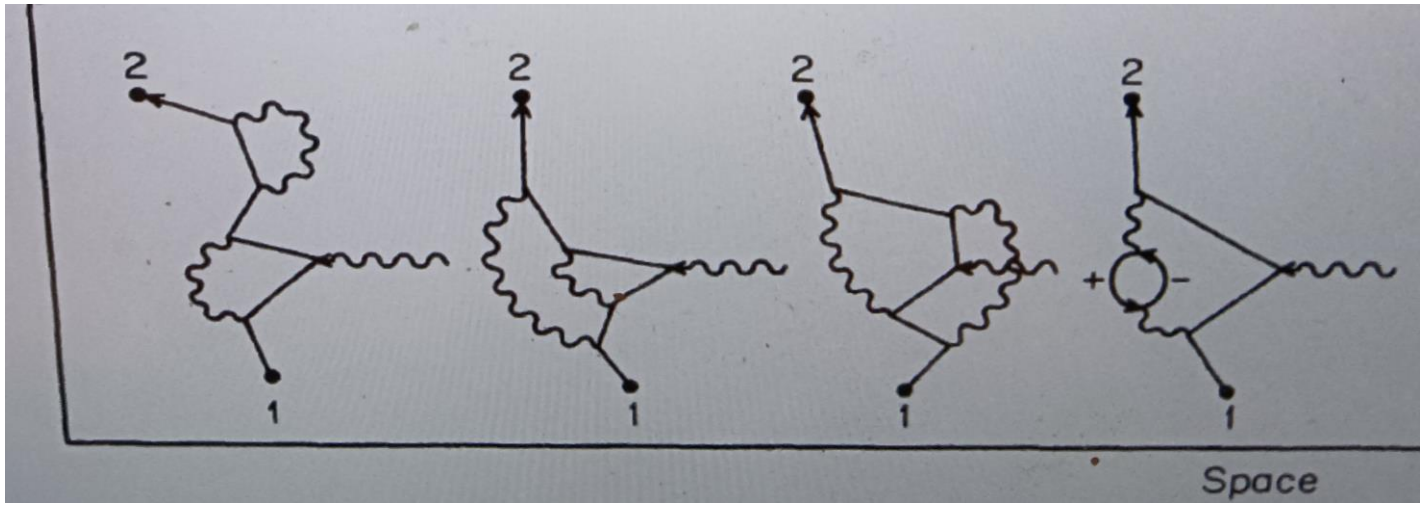
Dirac



Schwinger



Feynman Integrals and Renormalization bb



$$\mu_0 = \frac{e\hbar}{2m_e c}$$

$$\mu_e' = \left(1 + \frac{\alpha}{2\pi}\right)\mu_0$$

$$\mu_e = \left[1 + c_1\frac{\alpha}{\pi} + c_2\left(\frac{\alpha}{\pi}\right)^2 + c_3\left(\frac{\alpha}{\pi}\right)^3 + c_4\left(\frac{\alpha}{\pi}\right)^4 + \cdots\right]\mu_0$$

Real Picture of Free Electron

$$\mu_e = \left(1 + \frac{\alpha^*}{2\pi}\right)\mu_0$$

$$\frac{\alpha^*}{\alpha} = 0.998486708310$$

Just like electromagnetic wave, particle wave is also real vibration traveling in vacuum, it is generated by disturbance of particle motion on vacuum media.

The wavepacket of a moving charge consists of two orthogonal components: the original wave produced in the global vacuum with phase velocity $V_u > 10^4 c$, which then produce the longitudinal electric wave in the local vacuum with phase velocity c. the longitudinal wave further induce the transverse electromagnetic wave in the local vacuum.

Thank You !