Transmitting Matter by Using Space-Varying Probability

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Abstract: Macro matter has a definite path, howerver, micro matter does not have a clear moting path because it has a fundamental property i.e. the duality of wave and particle. Based on the difference between macro matter and micro matter, we propose the concept of transmitting matter by using space-varying probability. After we solve Schrödinger equation of the unequal doublee-δ potential, we demonstrate the main process of transmission via space-varying probability. We point out three main results for probability transmission: (1) the transmission distance does not have any limit, (2) the transmission system will emit a phonon at the end of transmission process. (3) the tansimission velocity is de Broglie matter wave phase velocity which may be larger many times than light speed in vacuum.

Key words: transmitting matter, probability, unequal double-δ potential, de Broglie matter wave phase velocity, light speed in vacuum

0 Introduction

There are many kinds of matter motions in the classic world, such as a rocket flying in the sky, a car running on the highway and Lionel Andrés Messi playing football in the football court. In such motions matter is transmitted and always has a definite path. You know that a football has a clear path, so Messi can take a football to enemy penalty area, and then finish a shoot or an assist. The conservation of momentum and energy, Newton laws determine the states of matter. The duality of wave and particle of particles is remarkable in the microcosmic world. Quantum mechanics replaces Newton law and has a dominated status. A micro particle does not have a definite path, based on the duality of wave and particle of micro particle, Schrödinger founds wave mechanics in 1926[1,2,3,4] independent of Heisenberg, Born and Joran's matrix mechanics[5,6,7] and Dirac's quantum Poisson bracket theory[8] in 1925. Born probability becomes an appropriate term to describe matter distribution[9] in 1926. In this contribution we put forward that probability can be used to transmit matter. Inspired by hydrogen-molecule ion H_2^+ model[10], the unequal double-δ potential model is adopted to demonstrate the transmitted process. The transmission velocity is discussed.

I. Solution of Schrödinger Equation for unequal double-δ potential

A particle is traped by $-V_0\delta(x+a)$ at the position $-a$ at first shown in Fig.1, after working out the steady state Schrödinger equation[11], the bound energy is only one, i.e. $E_0 = -\frac{\hbar^2 k_0^2}{2m} = -\frac{mV_0^2}{2\hbar^2}$ with $k_0 = mV_0/\hbar^2 = 1/b$, and the corresponding eigenfunction is

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$$\varphi(x)=\begin{cases}\sqrt{k_0}e^{-k_0(x+a)} & x>-a \\ \sqrt{k_0}e^{k_0(x+a)} & x<-a\end{cases}. \quad (1)$$

The value of b is regarded as the characteristic length of δ potential. The probability finding the particle in $-a-b<x<-a+b$ is $2\int_{-a}^{-a+b}k_0e^{-2k_0(x+a)}dx=1-e^{-2}=0.8647$. Now the other $-nV_0\delta(x-a)$ potential with real number $n>1$ is prepared at the position a. The particle will have a steady distribution, the eigenvalue of the unequal double-δ potential is $E=-\frac{\hbar^2k^2}{2m}$, and the equation about k is

$$n\exp(-4ka)=(kb-1)(kb-n). \quad (2)$$

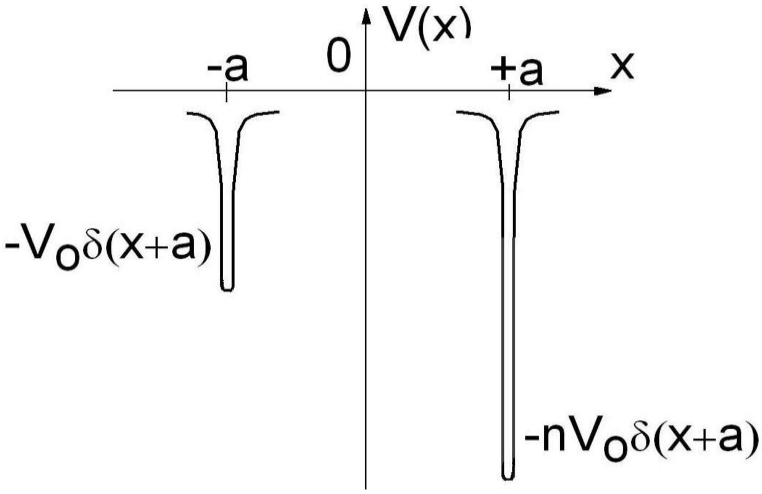

Fig.1 the unequal double-δ potential transmits a particle via space-varying probability

The solution of equation (2) has two or three roots, one is $k=0$ and the other two roots can be worked out by means of numeric calculation or graphing method. The first root $k=0$ should be abandoned from physics consideration. The other two roots are the abscissas of the crossover points of function $\eta(k)=n\exp(-4ka)$ and function $\eta'(k)=(kb-1)(kb-n)$. From the definition $\xi\equiv ka$ equation (2) will be $n\exp(-4\xi)=(\frac{b}{a}\xi-1)(\frac{b}{a}\xi-n)$. The typical two situations i.e. $0<\frac{a}{b}<\frac{n+1}{4n}$ and $\frac{a}{b}>\frac{n+1}{4n}$ are shown in Fig.2. The above conditions are derived from the compare between the slopes of the two curves at $\xi=0$. There is only one eigenvalue in $0<\frac{a}{b}<\frac{n+1}{4n}$, and one easily gets $\xi>\frac{a}{b}n$ i.e. $k>\frac{n}{b}$, accordingly the eigenvalue $E<-\frac{n^2\hbar^2}{2mb^2}=-\frac{n^2mV_0^2}{2\hbar^2}$. There are two eigenvalues in the situation $\frac{a}{b}>\frac{n+1}{4n}$. The first eigenvalue is the same to the above result $E_1<-\frac{n^2\hbar^2}{2mb^2}=-\frac{n^2mV_0^2}{2\hbar^2}$ in

$0<\frac{a}{b}<\frac{n+1}{4n}$, and the second eigenvalue should be $-\frac{mV_0^2}{2\hbar^2}<E_2<0$ from $0<\xi<\frac{a}{b}$ i.e. $0<k<\frac{1}{b}$.

The eigenfunction in both situations has the same form as follows

$$\psi(x)=\begin{cases} Ae^{kx} & x<-a \\ B_1e^{kx}+B_2e^{-kx} & -a<x<a \\ Ce^{-kx} & x>a \end{cases}. \qquad (3)$$

The wavefunction satisfies the following conditions besides continuity at $x=\pm a$

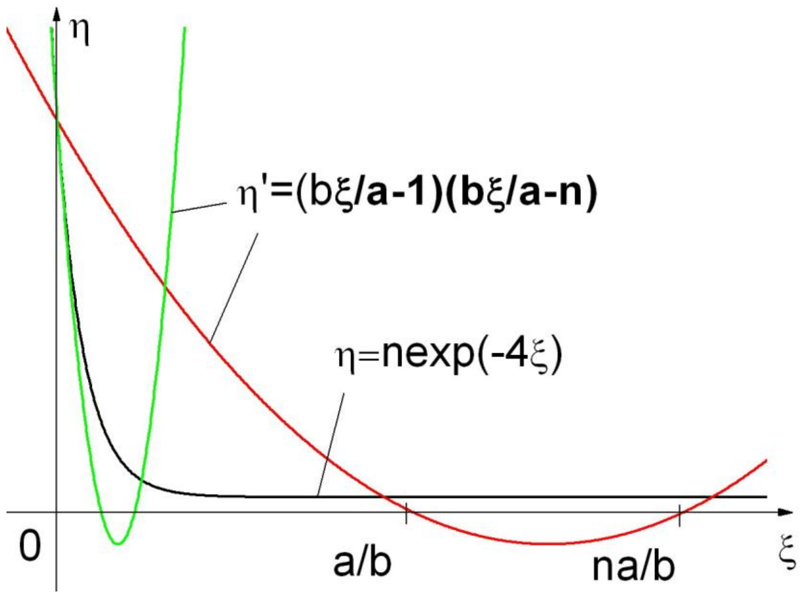

Fig.2 Eigenvalues of the unequal double-δ potential can be calculated from the crossover points of the curves $\eta(k)=n\exp(-4ka)$ and $\eta'(k)=(kb-1)(kb-n)$

$$\begin{cases} \frac{d\psi(-a^-)}{dx}-\frac{d\psi(-a^+)}{dx}=\frac{2}{b}\psi(-a) \\ \frac{d\psi(a^-)}{dx}-\frac{d\psi(a^+)}{dx}=\frac{2n}{b}\psi(a) \end{cases}.$$

The relationships of A, B_1, B_2 and C are

$$\begin{cases} A=B_1\frac{kb}{kb-1} \\ B_2=B_1\frac{e^{-2ka}}{kb-1} \\ C=B_1e^{-2ka}(e^{4ka}+\frac{1}{kb-1}) \end{cases}. \qquad (4)$$

B_1 can be arrived from wavefunction normalization condition $\int\psi^*\psi dx=1$, however, the value B_1 is not of importance in our question. When the half-distance a

is large, the second eigenvalue tends to the situation of one δ potential and correspondingly the condition $kb \sim 1$ must be satisfied. The probabilities except $-a$ all tend to infinity, we do not think that it is a physical result. Another reason is that the eigenvalue in this situation is higher than that of the other situation $k > \frac{n}{b}$. In the following discussion we only focus on the situation where the eigenvalue tends to $-\frac{n^2 m V_0^2}{2\hbar^2}$ i.e. $kb \sim n$.

II. Transmitting Matter by Using Space-varying Probability

The probability finding the particle in $-a-b < x < -a+b$ is about $2\int_{-a-b}^{-a} A^2 e^{2kx} dx = A^2 \frac{e^{-2ka}}{k}(1-e^{-2kb})$, and the probability in $a-b < x < a+b$ is about $2\int_{a}^{a+b} C^2 e^{-2kx} dx = C^2 \frac{e^{-2ka}}{k}(1-e^{-2kb})$. The probability ratio in $a-b < x < a+b$ and in $-a-b < x < -a+b$ is about

$$\frac{C^2}{A^2} = \frac{(kb-1)^2 e^{-4ka}[e^{4ka} + 1/(kb-1)]^2}{(kb)^2}. \tag{5}$$

When real n is invariant, k is determined and has definite values close to $1/b$ (without further consideration) or n/b. As long as the real n satisfies $n > 1$, the probability ratio C^2/A^2 will increase exponentially with the increase of the half distance *a*. As a matter of fact the roots $\xi \equiv ka$ of equation (2) should be $\xi > \frac{a}{b} n$, so $kb > 1$ is ensured and the above conclusion is valid seen from equation (5). The conclusion tells us that people do not need to pay great cost in order to acquire the great probability ratio. The condition $n > 1$ is enough, especially when the half distance *a* is large. Without loss of generality, we suppose that $n = 2, a/b = 2$ and obtain $kb \sim 2$ *and* $ka \sim 4$ .The probability density $|\psi(x)|^2$ is shown in Fig.3. From Fig.3 and equation (5) one observes that the probability finding a particle in $a-b < x < a+b$ (because of $a/b = 2$, the condition becomes $1 < x/b < 3$) is about $e^{16}/4$ times larger than that in $-a-b < x < -a+b$ ($-3 < x/b < -1$). It is very likely that matter can be transmitted by means of space-varying probability generated by the other $-nV_0\delta(x-a)$ potential.

How fast is matter transmitted via space-varying probability? Firstly a particle in $-V_0\delta(x+a)$ at $-a$ has a steady distribution, its wavefunction $\varphi(x)e^{-iE_0 t/\hbar}$ suggests that the wave at $-a$ is just a vibration and does not propagate along x axis. After the other $-nV_0\delta(x-a)$ at a was prepared, the distribution of the particle has been changed and the system has a lower energy tending to $-\frac{n^2 m V_0^2}{2\hbar^2}$ compared with the

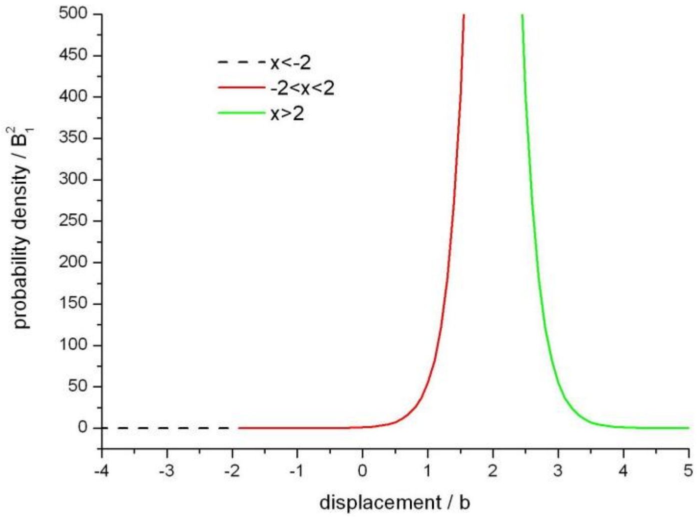

Fig.3 probability density varies with displacement, where the constant B_1^2 is to be normalized and the unit of displacement is b, i.e. the characteristic length of δ potential

initial energy $-\frac{mV_0^2}{2\hbar^2}$. Schrödinger equation $i\hbar\frac{d\psi}{dt}-H\psi=0$ does not have a source just as Maxwell equation or Einstein equation, so the wavefunction propagates from –*a* to *a* directly without any radiation process. As we know, the propagation velocity of a plane monochromatic wave $Ae^{i(px-Et)/\hbar}$ is $u=\frac{x}{t}=\frac{E}{p}=\frac{mc^2}{m\upsilon}=\frac{c^2}{\upsilon}>c$ which is de Broglie phase velocity[12]. Because a general wavefunction can be expanded to the form of plane monochromatic wave via Fourier transformation, we conclude that the velocity of the wavefunction propagating from –*a* to *a* should be larger than light speed c. When the particle has a new steady distribution in the unequal double-δ potential, the wavefunction becomes a pure vibration and does not propagate along x axis. There are three questions to be discussed. Firstly we do not have any constraint about transmitted distance 2*a*, it means that the distance can theoretically be arbitrary. Secondly the final state of the system has a lower energy $-\frac{n^2mV_0^2}{2\hbar^2}$ compared with the initial energy $-\frac{mV_0^2}{2\hbar^2}$, so the system will radiate a photon which frequency is $\nu=(\frac{n^2mV_0^2}{2\hbar^2}-\frac{mV_0^2}{2\hbar^2})/h=\frac{mV_0^2(n^2-1)}{4\pi\hbar^3}$ when the transmitted process ends. In fact it is regarded as a successful signal of the transmitted process that the photon appears. Finally it is noted that if Bob tells his location at +*a* to Alice at –*a* via radio communication, the velocity of transmitted information can not exceed light speed and our theory do not violate special relativity.

III. Summery

Transmitting matter by using space-varying probability is a new way to move matter from one point to the other point, it is a full quantum effect. This new effect is not seemed difficult to be verified, for example the electron in a neutral alkali atom will be immediately trapped by a strong Coulomb field i.e. U^{92+} in electron beam ion traps(EBIT)[13]and the system radiates a photon simultaneously. Of course, it is not too easy that experimental conditions are well met. In principle it is possible that the velocity of transmitting matter is larger that light speed, what's more, the velocity of transmitting matter via space-varying probability could also be larger than that of neutrino[14]. When people operate gravitational force, based on our theory, it is no longer only a dream to realize star trek. Unfortunately, if a thief learns our theory, be careful, your wallet is to be stolen in teleportation!

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使用空间可变几率传输物质

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摘要：宏观物质有确定的轨迹，而微观物质由于其波粒二像性没有一个明确的运动轨迹。基于宏观物质和微观物质性质的不同，我们提出了使用空间可变几率传输物质的概念。在求解不等高双δ 势的薛定谔方程后，阐述了几率传输物质的主要过程。我们指出了该机制传输物质三个主要的结果：（1）传输距离不受任何限制，（2）在传输过程结束时传输系统会发出一个光子，（3）几率传输物质的速度是比真空中光速大得多的德布罗意物质波的相速度。

关键词：传输物质，几率，不等高双δ 势，德布罗意波相速度，真空中的光速
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