

Speculation on the Quantum Wavelength as Related to an Impulse

Francesco R. Ruggeri Hanwell, N.B. Oct. 8, 2021

A point electron has spin $\frac{1}{2}$ which is sensitive to all three dimensions of space as one may have spin projections about any axis. The electron is also said to have a wavefunction $\exp(ipx)$ (where the momentum lies in the x direction) and a wavelength L where $p = 2\pi\hbar/L$. In this note, we argue that like spin, the momentum property is sensitive to three dimensions of space. Furthermore we argue that the form $\exp(ipx)$ is a conditional probability linked to an impulse i.e. $-d/dx \exp(ipx) = -ip \exp(ipx)$ reminiscent of $-dV/dx$. In other words we argue that when an electron interacts, it does so through impulse hits (as opposed to accelerating as in classical mechanics). In order to create a force $-dV/dx$ we argue that its probability is linked to V or probability so for a high p there must be a high slope or a very small wavelength. For the case of a two slit experiment, a single electron interacts with both slits if they are within a wavelength apart and tries to create a kind of potential based on impulse hits by establishing $\exp(ipx)$ in both slits instead of being linked to a pilot wave.. Interference occurs because impulse hits (force) adds or subtracts.

Electron Momentum and Three-Space

In a previous note (1) we argued that electron spin senses all three directions of space. There are spin projections about any axis. A spin projection only occurs when there is an interaction with a $V(x)$, eg. a magnetic field. Similarly we argue that the wavelength related to momentum ($p = 2\pi\hbar/L$) is also linked to three space (although in (1) we stated it was really one dimensional along the direction of momentum). Wavelength does seem to be linked to the direction of p (as wavelength patterns appear in the one dimensional infinite well with p in the direction of the pattern). An electron passing through two slits, however, senses the distance between the slits even though this distance is perpendicular to its motion. There is a degeneracy as the two slits may be in any direction in a plane perpendicular to the motion, as an example. This degeneracy, however, is only considered as one dimension, it seems, with the second being along the direction of motion. Thus, one has the two dimensional:

$$\exp(ipx) = \cos(px) + i \sin(px) \quad ((1))$$

We argue that loss of probability along the axis of motion is due to the electron having probability to be in a direction perpendicular to this motion. (Thus, it could pass through one slit or the other.) Overall probability must be conserved so the modulus of $((1))$ is one.

Potential

The potential in classical mechanics serves to accelerate a particle, but this does not happen in quantum mechanics except in average e.g. an acceleration emerges from $KE(x) = [-1/2m d/dx dW/dx]/W$ where W is the wavefunction although in a root mean square sense. A different scenario is necessary. We have argued in previous notes (2) that $V(x)$ is a sum of impulse hits,

each delivering a different k with its own probability. On average they recreate $V(x)$ i.e. $\sum_k V_k \exp(ikx)$. We argue that the quantum particle, which also interacts and serves to create force in terms of impulses because it has momentum, should also be of the form $\exp(ipx)$. The spatial periodic behaviour is due to keeping the form: $\text{Force} = -dV/dx$, so the probability (which is like a potential) must drop sharply for high p i.e. have a high slope. This probability $\exp(ipx)$ is used to create average $KE(x)$ which is added to $V(x)$, so we argue that it is of a similar nature to $V(x)$ otherwise the two should not be added.

$$KE(x) = [\sum_p a(p) \exp(ipx) p^2 / 2m] / [\sum_p a(p) \exp(ipx)] \quad (2)$$

Two dimensions are needed to ensure probability is conserved i.e. the modulus of $\exp(ipx)$ is one. We have argued in the previous section that the two dimensions consist of the direction of p and the plane perpendicular to p (which is treated as one dimension (i.e. there is degeneracy in that plane similar to the electric field or magnetic field in a photon). The unusual behaviour of the probability of an electron i.e. $\exp(ipx)$ is due to the particle trying to establish a momentum (impulse) hit potential profile in the presence of another potential $V(x)$ or a two slit geometry etc.

Two Slit Experiment

First the idea of momentum sensing all three dimensions of space may be tested, it seems, by having two slits oriented in different directions in a plane perpendicular to electron motion. A single electron should be able to sense two slits perpendicular to its motion if the slits are a wavelength or less apart. The quantum particle tries to create an impulse potential pattern in the region of the two slits with $\exp(ip \cdot \text{xvector1}) + \exp(ip \cdot \text{xvector2})$, one for each slit where xvector1 and xvector2 range from each slit to a fixed point near the slits. These interfere (add subtract) because impulses also add and subtract. (One does not need to go to a screen far away to see the interference pattern i.e. the impulse hit potential profile.) We argue that an interference pattern should be established at the two slits. (It later extends to a screen at a certain distance away.) Unlike a pilot wave guiding the electron (de Broglie (3)), we argue that the electron tries to create a potential field based on impulse hits and must do so within the geometry of the two slit situation.

The modulus of the sum $\exp(ipx)$'s is again taken to find the overall probability. Regions with no particle probability (i.e. dark spots in an interference pattern) occur because a quantum particle tries to create an impulse hit profile which requires a changing density. This leads to regions with very little probability.

Separation of Time

An interesting feature of time-independent quantum mechanics is the separation (removal) of time, even though classically time should appear. For example, particle moving in an infinite potential well is either moving in a forward or backward manner and these are linked to two mutually exclusive time ranges. A quantum particle also has forward and backward motion with $\exp(ipx)$ and $\exp(-ipx)$, but these are allowed to interfere as if time does not matter. We argue that this occurs because the particle is trying to establish an impulse potential pattern i.e. that is

the meaning of the wavefunction. For a potential, one does not follow time even though there may be dynamic events occurring within such a potential even if it is $V(x)$. Thus $\exp(ipx) = \cos(px) + i\sin(px)$ and $\exp(-ipx) = \cos(px) - i\sin(px)$ may interfere because the second dimensional “forces” from $i\sin(px)$ and $-i\sin(px)$ cancel.

Density in Averages

Quantum mechanics may be used to calculate average values in two different ways. First:

$$KE(x) = [\text{Sum over } p \ a(p)p^2/2m \exp(ipx)]/W(x) \quad ((3)) \quad \text{where } W(x) = \text{Sum over } p \ a(p)\exp(ipx).$$

$$\text{but then there is also } \langle KE \rangle = [-1/2m \ d/dx \ dW/dx] / W \quad ((4))$$

In the first case one has a quantum average which reproduces classical values, but one has no sense of the impulse potential field (hence density being established) from the final average value. ((4)), however, shows explicitly that a quantum particle tries to create an impulse potential profile which automatically leads to a spatial density if $-d/dx$ probability is to be proportional to p probability where p = momentum is the impulse hit.

Transition Probabilities

Two impulse hits of p_1 and p_2 are equivalent to an impulse hit of $p_1 + p_2$ (vectors). Thus $\exp(ip_1x)$ and $\exp(ip_2x)$ as probabilities when taken in an AND situation yield a combined impulse. This allows one to write:

$$V(x)W(x) \text{ as a product of impulse hits which yields a new overall impulse pattern } \quad ((5))$$

In other words we argue that both $V(x)$ and $W(x)$ are both impulse hit profiles.

If one has an impulse hit (potential) profile of $W^2(x)$, one may see how it is related to ((6)) by taking the overlap:

$$\langle W^2(x) | V(x)W(x) \rangle \quad ((6))$$

In other words $V(x)W(x)$ which is an impulse hit potential profile is also a probability (or sum of probabilities) and may contain $W^2(x)$ within as well as other pieces. The overlap picks up the weight of the $W^2(x)$ piece contained within $V(x)W(x)$. ((6)) must be squared (modulus squared) in order to find the overall probability just as $\exp(ipx)$ must be squared (i.e the modulus must be taken).

Conclusion

In conclusion, we argue that a quantum particle, like a potential $V(x)$, tries to create an impulse hit (potential) profile using spatial probability. If $\text{Force} = -dV/dx$ and $V(x)$ is treated as a

spatial probability as in $V(x) = \sum_k V_k \exp(ikx)$, a quantum particle may create the same probability profile i.e. try to establish its own impulse potential hit profile i.e. $\exp(ipx)$ or $W(x) = \sum_p a(p) \exp(ipx)$ or a sum based on geometry such as in the two-slit scenario.. The wavelength appears i.e. probability drops in x , because a slope must be established for the impulse hit to be given. The sharper the slope, the higher the impulse hit. Two dimensions are needed because probability must be conserved i.e the modulus of $\exp(ipx)$ is 1. We argue that an electron (or other quantum particles) may sense three-space, but $\exp(ipx)$ is a two vector. One dimension is in the direction of momentum p , and the other is a degenerate direction in a plane perpendicular to p much like the electric and magnetic fields in a photon. In the case of the two slit experiment, this sensing of space perpendicular to motion allows the electron (quantum particle) to sense slits which are separated by the wavelength or less. An impulse hit potential profile is established by a single electron (quantum particle) using both slits. Thus there is interference because force adds/subtracts to create a pattern with peaks and troughs.

References

1. Ruggeri, Francesco R. Quantum Spin and Information (preprint, zenodo, 2021)
2. Ruggeri, Francesco R. Time Base Force (Impulse) Versus Space Base Force ($-dV/dx$) in Classical and Quantum Mechanics (preprint, zenodo, 2021)
3. https://en.wikipedia.org/wiki/Pilot_wave_theory