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Research Article

A PHYSICAL ANALYSIS OF SPINORS IN THE CONTEXT OF VECTOR THEORY: THE SPINOR AS A COLUMNAR VORTEX

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ABSTRACT

The spinor is a well-known mathematical object in Quantum Physics however it is difficult to understand in terms of everyday experience and this has created a barrier to understanding them for many people. However, the spinor can now be understood through physical vector analysis. A spinor is a vector that obeys Mach's Principle, it is connected to the surrounding cosmos. Simply put in mathematical terms : a spinor is combination of an arrow vector and a spin vector with axis aligned along that arrow vector, as seen in the flow structure of a columnar vortex. Looked at in this way, examples of spinors are all around us in nature and represent a melding together of dynamics, structure, and persistence: the dust devil or fire whirl as seen in a field , a spinning propeller shaft of a racing boat, a photon of circularly polarized light, a cyclone or a galaxy. All of these objects have complex details, but are basically composed of linear motion combined with circular motion. Thus a thermal updraft is vector flow but combined with vortex flow is a dust devil or tornado and thus a spinor. The mathematical structure of spinors is very interesting and can actually be basically understood from the same vector analysis that is employed in solving many everyday problems in physics and engineering.

Keywords: spinor, Mathematical, complex numbers, antiparallel.

INTRODUCTION

The spinor is a well-known mathematical object in Quantum Physics [1] however it is difficult to understand in terms of everyday experience and this has created a barrier to understanding them for many people. However, the spinor can now be understood through physical vector analysis. A spinor is a vector that obeys Mach's Principle, it is connected to the surrounding cosmos. Simply put in mathematical terms : a spinor is combination of an arrow vector and a spin vector with axis aligned along that arrow vector, like the flow structure of a columnar vortex. Others have described it as a "flagpole with a flag" with the flagpole defining the arrow vector and the flag determining a rotation around the axis defined by the flagpole [2]. Looked at in this way, examples of spinors are all around us in nature and represent a melding together of dynamics, structure, and persistence: the dust devil or fire whirl as seen in a field , a spinning propeller shaft of a racing boat, a photon of circularly polarized light, a cyclone or a galaxy.(see Figure 1.) All of these objects have complex details, but are basically composed of linear motion combined with circular motion. Thus a thermal updraft is vector flow but combined with vortex flow is a dust devil or tornado and thus a spinor. The mathematical structure of spinors is very interesting and can actually be basically understood from the same vector analysis that is employed in solving many everyday problems in physics and engineering.

Figure 1. Examples of Spinors

Vector analysis is extremely useful for analyzing and solving complex problems in reality. Vectors can, of course, be divided into two types: polar (ordinary) vectors , which can represent location, force, or electric fields, and axial (pseudo) vectors which can represent rotation, vorticity, or magnetic fields. In normal experience these two types of vectors are easily differentiated but mathematically they can be separated by viewing them in a mirror. If one stands in front of a mirror and points one's right thumb, in "hitchhikers" form with fingers curled, at the mirror, one sees the thumb direction , a polar vector, reversed and pointing back at oneself. However, the "curl" axial vector of the fingers, (whose direction is assigned by the right hand rule) is unchanged in the mirror and still points away from you. The mirror image we see is a 'reflection transformation' of coordinates, which if we assign the familiar unit vectors **I, j, k** representing x, y and z directions in space respectively, with x and y here representing up and down and side to side in the mirror respectively, , then z is the vector direction into the mirror, with **k** becoming **- k** which is being reversed in the image, but **i** and **j** are left unchanged. If we have a camera facing us with screen set up beside the mirror, to show what it sees, we will see once again the polar vector of thumb reversed, but now the curl axis of one's fingers is also reversed , because **j** has also become –**j** additionally, because y is also reversed in the camera

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image along with z. These images, the camera and mirror image can be seen in Figure 2. Some will complain that mirror image is unphysical, but this is only until the power to the camera fails and only the mirror image remains. The mirror image is as physically real as throwing a tennis ball at a wall, and having bounce back and hit you. We can now use these vector concepts to construct a spinor.

Constructing a Spinor Using Ordinary Vector Analysis.

We begin with basic model of a spinor composed of two vectors of equal length (magnitude) so that the polar vector $\mathbf{v_p}$ and axial vector $\mathbf{v_a}$ have lengths $v_p = \frac{1}{2}$ and $v_a = \frac{1}{2}$ respectively. We now view the spinor in both a mirror and through a camera image.

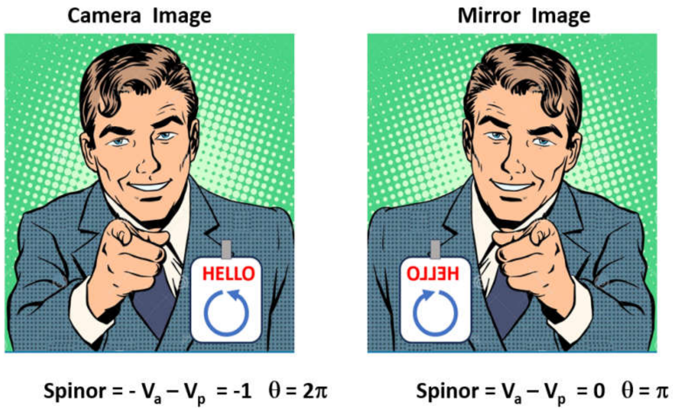

Figure 2. (L) Camera Image, what others see. (R) Mirror image.

The simple spinor we have constructed and demonstrated by the index finger direction (the polar vector) and the badge symbol showing rotation direction (the axial vector) show how the spinor length can become zero in the mirror image, and reverse completely in the camera image. The length of the spinor in the mirror image can be generalized as a function of θ, the angle between the original polar vector and that in a mirror rotated from being on the ceiling to finally face the observer. The value of $\theta = \pi$ radians, with $\cos\theta = -1$ gives the mirror image. In the mirror image the polar and axial vectors cancel and the length of the spinor becomes zero , as shown in Figure 2.. The value of ½ represents the unchanged length of the axial vector during this mirror rotation.

$$\frac{1+\mathrm{Cos}(\theta)}{2} = \mathrm{Cos}^2\left(\frac{\theta}{2}\right) \quad (1)$$

This is the fabled "Half Angle" formula so often associated with spinors. For the case of the camera image the length of the axial vector is given by the cross product of two vectors in the plane of the images, one in the x direction v_x (side to side) and the other in the y direction v_y(up and down):

$$v_a\mathbf{k} = v_x\mathbf{i}\mathbf{x}v_y\mathbf{j} \qquad (2)$$

If the x vector is reversed , as in the camera image, we have $v_x \rightarrow -v_x$ and therefore, $\mathbf{v_a} \rightarrow -\mathbf{v_a}$. and the spinor now has the length of -1. Thus, we must rotate both parts of the spinor, the polar vector portion, and the axial vector portion, each by $\theta = \pi$, to reverse the spinor. We must do this two-step process again to return the spinor to its original starting point. This requirement of a two independent step process, for rotations, is the source of the half angle phenomenon of spinors. But what is its physical meaning of this mathematical trait?

This double 2π rotation requirement, to rotate a spinor back to its starting point is due to the fact that a spinor is not an isolated vector, but is connected to the cosmos around it. Spinors thus obey Mach's Principle, where local physics is determined by the physics of the surrounding cosmos. A polar vector is flying smoothbore musket ball, a spinor is rifle bullet. Just as musket ball can change its attitude freely and still follow its same course, it is effectively decoupled rotationally from its surroundings. Not so with a spinning rifle bullet, it is a gyroscope, as well as a moving mass. To change the course of rifle bullet one must change not only its momentum, a polar vector, but also its angular momentum, an axial vector. This is not just true of spinning objects but also any object subject to rotations that is connected to its surroundings. A human hand (connected to its body!) is thus a spinor.

For a human hand the direction of the thumb (and attitude of the knuckles (up or down) together define an axial vector which defines the rotation of the hand relative to the body with the shoulder as the origin. We can, with the palm of the hand oriented upraised and below our shoulders, rotate the hand through angle $\theta = 2\pi$with only minor difficulty. Doing this literally 'twists one arm.' But one cannot rotate it further- it is connected to the pivot point of the shoulder which remains stationary. We can then however, raise the hand above our head, still palm up, and once it is there, rotate it in the same rotation direction as before, but this action, seemingly by magic, 'untwists your arm'. The fact that the rotation of direction is unchanged can be interpreted as making the whole operation as a double rotation, when a more everyday interpretation is that somehow the second $\theta = 2\pi$ rotation is in fact of negative sign and cancels the previous rotation. This twist and then untwist operation is the unambiguous interpretation of the nerves in our arm. Mathematically, it is the raising of the plane of rotation from below the plane of the shoulders, with a fixed pivot point at the shoulder, to above the shoulders that causes this reversal of sign,-turning the twist into an untwist while preserving the same direction of rotation. Accordingly, the 4π twist required to bring the spinor back to its initial state is due to a "spin axis" flip that must occur in the process, due to the connection to the surrounding cosmos. Thus, the first 2π twist is undone by what becomes a 2π untwist in the second part of the rotation. This subtle reality of rotations coupled to orientations is the basis for the beauty of the "Sumatran Candle dance, " illustrated in Figure 4.

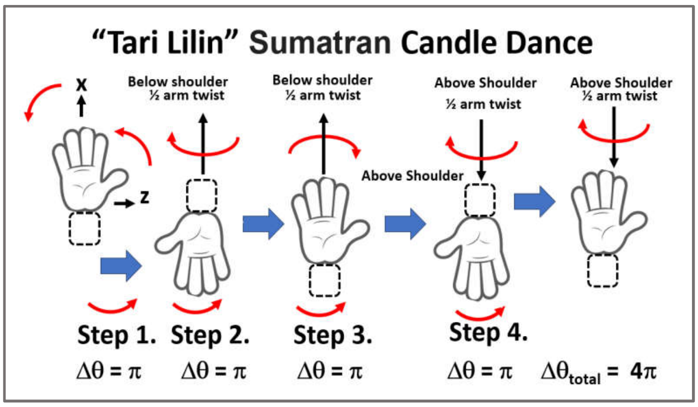

Figure 3. The Sumatran Candle Dance which accomplishes the 4π rotation of the hand, but with the crucial middle step of raising the upturned hand from below the shoulders to above them, thus reversing the mathematical sense of the rotation while appearing to continue its direction.

This phenomenon can be easily seen with small nut and bolt, with the head of the bolt facing downward away from us. A downward torque, defined with the right hand rule, moves the nut towards the head of the bolt, 'tightening it'. Now, if the bolt is reversed and its head points upwards at us, and the downward torque is again applied, the nut moves away from the head of the bolt 'loosening it' So the same torque direction either tightens or loosens the nut depending on the coordinate orientation of the bolt, either up or down relative to us.

A Basic Mathematical Discussion

We have proposed a simple model of a spinor is three space as a polar vector combined with a parallel axial vector. We will assume here that we are free to define any vector through coordinate rotations as a vector only in the z direction. We can then create a compact representation of a basic spinor in the z direction, from a basic unit three vector multiplied by a matrix, with the added convention that the x and y components will then form a cross product to supply the axial portion.

$$\begin{bmatrix}0 & -1 & 0\\ 1 & 0 & 0\\ 0 & 0 & 1\end{bmatrix}\begin{bmatrix}1\\1\\1\end{bmatrix} = [-1 \quad 1 \quad 1] \qquad (3)$$

We can consider this representation in short-hand form as a complex vector in the z direction, with a magnitude consisting of real and imaginary parts,

$$1 + \mathrm{i} = \begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} + \begin{bmatrix}0 & -1\\ 1 & 0\end{bmatrix} \qquad (4)$$

where the real numbers and imaginary number **i**can be represented as a matrices. It can be quickly verified that

$$1\mathrm{i} = \begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}\begin{bmatrix}0 & -1\\ 1 & 0\end{bmatrix} = \begin{bmatrix}0 & -1\\ 1 & 0\end{bmatrix} \qquad (5)$$

Also we have the completed algebra for i

$$\mathrm{i}^2 = \begin{bmatrix}0 & -1\\ 1 & 0\end{bmatrix}\begin{bmatrix}0 & -1\\ 1 & 0\end{bmatrix} = -\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} \qquad (6)$$

Accordingly, complex numbers can be considered as a combination of two matrix components.

We can consider this alternatively to be an abstract representation of a spinor where the real part is the height of the x y plane, z, and the imaginary part is a vector in the x y plane whose crossed x and y components form a axial vector also in the z direction. Defined in this way a three space spinor can be represented as a point in a complex 3 space, very basically similar to the "Twistor Space" proposed by Roger Penrose [3].

We can extend this physical picture tentatively even to the "Alice In Wonderland " realm of quantum Mechanics where quantum particles are identified mathematically as spinor objects, and where all stable particles possess spin. Photons, moving at the speed of light must have spin parallel or anti-parallel to their momentum vectors, agreeing with our physical picture of a spinor from everyday life. However, for particles with rest mass and spin, how can the spinor physical model of spin aligned with momentum be actualized if the particle, possessing mass, can therefore be at rest?

The answer, briefly, is found in the physical picture of particles in quantum mechanics as obeying the quantum uncertainty of Heisenberg, so they can never be at rest. In quantum mechanics all particles "quiver", or undergo "zitterbewegung" motion around a location even when classically at rest. In the mathematical model of Penrose [4] it is shown that the quantum electron exists in the Dirac model as a sort of interference pattern of massless quantum waves, which are never at rest and, which like photons must have spin parallel or antiparallel to their motion. Accordingly, the massless waves can interfere, creating , effectively, a moving mass with spin always parallel or antiparallel to their motion, and thus reflecting in the quantum world, our classical picture of spinors from everyday life, as a columnar vortex flow-like object. Therefore, just as the spinor allows a highly structured object to appear in "thin air", a supposedly structure-less medium , so does the spinor appear in the form of stable particle out of the seemly structure -less quantum fields.

SUMMARY

Therefore, the spinor can be understood in the simple terms of basic vector analysis, as being a polar vector combined with a parallel axial vector. A tornado is a spinor as opposed to simple thermal updraft, like a smoke column, which is just a polar vector. It is the axial portion of the spinor, because it carries spin or rotation relative to its surroundings, that connects the spinor to the rest of the cosmos. The polar vector thus creates locality, and the axial vector creates nonlocality. Accordingly, a spinor is thus a vector demonstrating the Mach Principle: the connection of local physics to cosmic physics. The spinor also demonstrates the power of nature to assemble coherent and persistent structures in structure-less media. Examples of such objects are common in both nature and human technology and often are associated with objects of great power and robustness. The importance of spinors in representations of particles in quantum physics, even if somewhat abstract, indicates, strongly, the utility of physical analogies from everyday human experience to understand objects on both the cosmic and microscopic scale.

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