THE REINTERPRETATION OF THE STERN-GERLACH EXPERIMENT

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ABSTRACT

This publication presents a mathematical approach for a reinterpretation of the Stern-Gerlach experiment, taking into account Faraday's unipolar induction, which has proven effective in practice. Another basis for this paper is the work "The Reinterpretation of the Einstein de Haas Experiment[1]". These two foundations, in combination with the rules of vector analysis, reveal a new interpretation of the Stern-Gerlach experiment. Faraday's unipolar induction provides a universally valid computational approach for the structure of an atom, which plays an important role in the Stern-Gerlach experiment. This, in combination with the reformulation of the magnetic moment from the paper "The Reinterpretation of the Einstein de Haas Experiment[1]", explains the behavior of atoms that are directed through an external inhomogeneous magnetic field in a straight path. As they pass through this magnetic field, they change their direction of motion.

It is shown that the change in the direction of motion of atoms can be mathematically derived and explained using these foundations. The mathematical description of the magnetic moment and its mathematical-physical consequences concerning the orientation of the magnetic moment will play a central role. It becomes evident that there must be two different types of atoms, each with an internal convention of "up" and "down" that is different. Furthermore, this provides a consistent and logically comprehensible description of the behavior of an atom, based on mathematics and classical physics.

1. INTRODUCTION

The Stern-Gerlach experiment was conducted by Otto Stern (February 17, 1888 – August 17, 1969) and Walther Gerlach (August 1, 1889 – August 10, 1979) in 1922. The experiment demonstrated that silver atoms, when passed through an external inhomogeneous magnetic field in a beam, change their direction of motion. The silver atoms in the beam move either towards the south pole or towards the north pole of the external inhomogeneous magnetic field. The interpretation of this effect must be that the particles possess a magnetic moment $\vec{m}$ that points either to the south pole or to the north pole (Fig. 1). The fact that particles possess a magnetic moment $\vec{m}$ is shown by the Einstein-de Haas experiment.

In the work "The Reinterpretation of the Einstein-de Haas Experiment[1]", the formulation for the magnetic moment $\vec{m}$ is recalculated, thereby explaining and correcting the factorial difference between the measurement and the calculation of the magnetic moment $\vec{m}$. This factor has a value of 2. This allows the magnetic moment $\vec{m}$ of a particle to be explained using the tools of classical physics. Therefore, it is appropriate to investigate the Stern-Gerlach experiment and formulate a mathematically and physically determined description of the behavior of an atom.

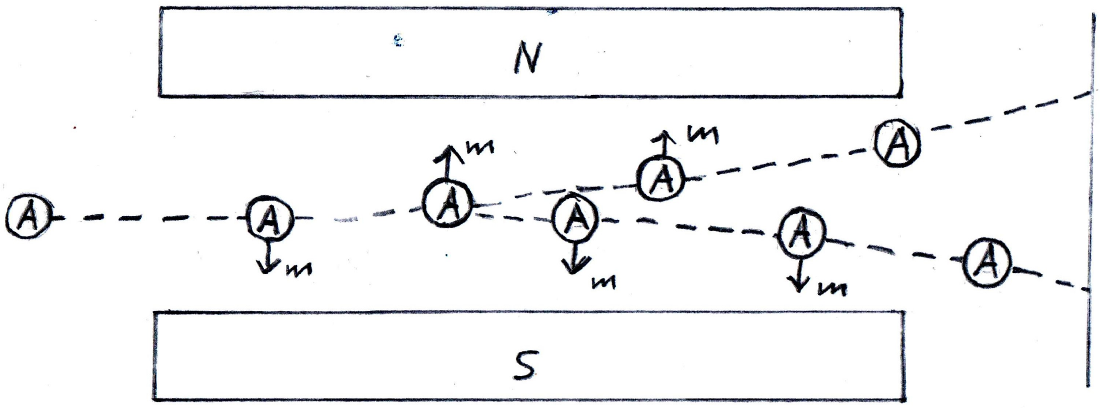

Fig.1 Stern-Gerlach experiment, source: own illustration

2. IDEAS AND METHODS

2.1 IDEA FOR REINTERPRETING THE STERN GERLACH EXPERIMENT

The idea for "The reinterpretation of the Stern Gerlach experiment" is based on the fact that atoms change their direction of movement when passing through an external, inhomogeneous magnetic field. Either towards the north pole or towards the south pole of this magnetic field. In combination with the correction of the formula for calculating the magnetic moment $\vec{m}$ from the Einstein de Haas experiment, which was carried out in the paper "The reinterpretation of the Einstein de Haas experiment[1]". It follows that a particle has a magnetic moment , $\vec{m}$ but no additional intrinsic magnetic moment. This magnetic moment $\vec{m}$ can be proven mathematically and physically, as shown in the paper "The reinterpretation of the Einstein de Haas experiment[1]". With the help of Faraday's unipolar induction and vector calculation, a formal description of the magnetic moment $\vec{m}$ of a particle can now be given. All physical and mathematical basic descriptions used in this work are listed below.

$\vec{E}$ = electric field strength
$\vec{D}$ = electric flux density
$\vec{v}$ = velocity
$\vec{H}$ = magnetic field strength
$\vec{B}$ = magnetic flux density
$\times$ = cross product
U = electrical voltage
$\vec{m}$ = magnetic moment
I = electrical current
$\vec{A}$ = area / area vector

Unipolar induction according to Farady:

$$\vec{E} = \vec{v} \times \vec{B} \qquad (2.1.1)$$

Magnetic field equation:

$$\vec{H} = -(\vec{v} \times \vec{D}) \qquad (2.1.2)$$

Magnetic moment[1]:

$$\vec{m} = 2I \cdot \vec{A} \tag{2.1.3}$$

2.2 BASICS OF VECTOR CALCULATIONS

In order to be able to derive the mathematical descriptions suitable for the reformulation of the Stern Gerlach experiment, the basics of vector calculation used for this purpose are described in this chapter.

First of all, three meta-vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ are introduced at this point. The three meta-vectors will be used in the following basic mathematical description. In Equation 2.2.1, these three meta-vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ are used to represent the cross product.

$$\vec{c} = \vec{a} \times \vec{b} \tag{2.2.1}$$

In equation 2.2.1 the three meta-vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$ are now replaced by the physical vectors $\vec{v}$, $\vec{B}$ and $\vec{E}$. This creates equation 2.1.1.

$$\vec{E} = \vec{v} \times \vec{B} \tag{2.1.1}$$

Equation 2.1.1 describes the Faraday unipolar induction. If the magnetic field vector and the vector for the electric field are swapped and the sign is changed, the equation that describes the magnetic field is created 2.1.2.

$$\vec{H} = -(\vec{v} \times \vec{D}) \tag{2.1.2}$$

The relationship between the electric field strength $\vec{E}$ and the electric flux density $\vec{D}$ is given by equation 2.1.3. The relationship between the magnetic field strength $\vec{H}$ and the magnetic flux density $\vec{B}$ is given by equation 2.1.4.

$$\vec{D} = \epsilon E \tag{2.2.2}$$

$$\vec{B} = \mu H \tag{2.2.3}$$

Equations 2.1.1 and 2.1.2 will be used in this work for the partial description of the atom. First of all, in Chapter 2.3, these two equations will be used in the description of Faraday's unipolar induction and the magnetic field equation.

2.3 THE UNIPOLAR INDUCTION AND THE MAGNETIC FIELD EQUATION

In order to explain why atoms that are guided through an external magnetic field change their direction of movement, the facts from equation 2.1.1 are first illustrated using the unipolar generator in Fig. 2.

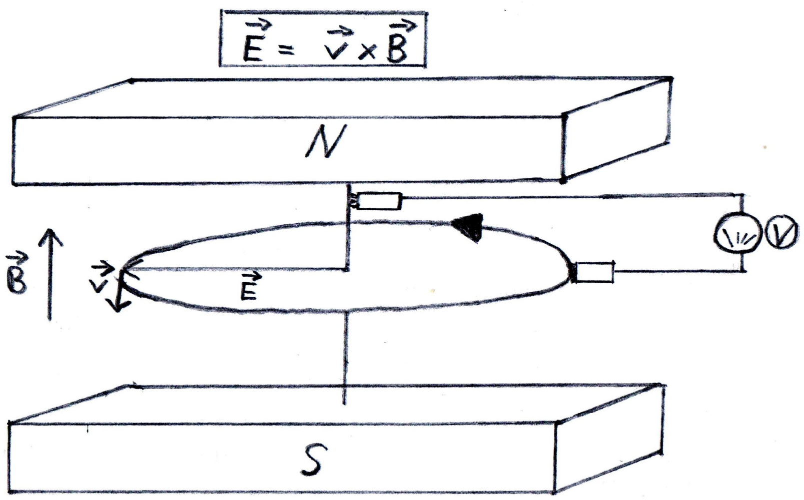

Fig.2 unipolar generator, source: own illustration

Fig. 2 shows that an electric field $\vec{E}$ and thus an electric voltage U is formed from the center to the edge of a copper disk that rotates through a magnetic field. The velocity vector $\vec{v}$ describes the direction and speed of rotation of the copper disk. The magnetic flux density $\vec{B}$ penetrates the entire surface of the copper disk. The magnetic field strength H can also arise when an electric flux density $\vec{D}$ is offset against the velocity vector $\vec{v}$ in the cross product. This is shown in Figure 3. The relationship between the electric field strength $\vec{E}$ and the electric flux density $\vec{D}$ is given in Equation 2.2.2 and the relationship between the magnetic flux density $\vec{B}$ and the magnetic field strength $\vec{H}$ is given in Equation 2.2.3.

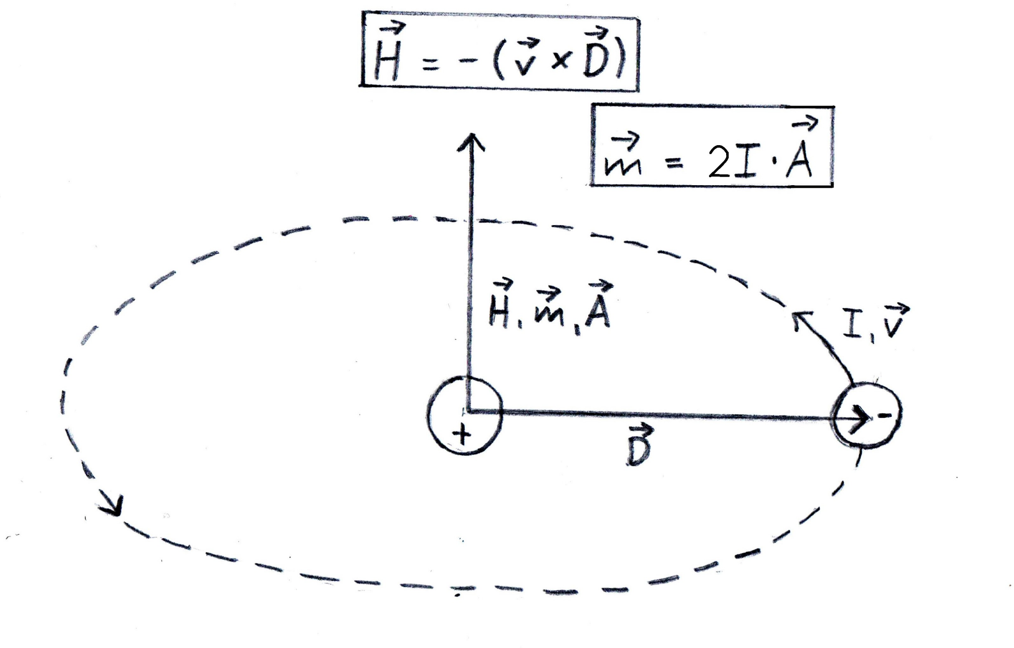

Fig. 3 magnetic field / atom model, source: own illustration

Fig. 3 shows that a magnetic field strength $\vec{H}$ is at a 90° angle to both the velocity vector $\vec{v}$ and the electric flux density vector $\vec{D}$. The electric flux density vector $\vec{D}$ lies here between the atomic nucleus, which is positively electrically charged (+) and the electron on the outer orbit, which is negatively electrically charged (-).

The rotation of the electron around the atomic nucleus then creates the magnetic field strength $\vec{H}$. Depending on whether the electron rotates left or right, the vector of the magnetic field $\vec{H}$ points upwards or downwards. This mathematically creates either a north pole or a south pole. In the case of the atom, both poles arise because a rotation of the electron around the center to the right when viewed from above represents at the same time a rotation to the left when viewed from below. The meaning of “above” and “below” will be discussed in the following chapters.

The atom model from Fig. 3 was expanded to include the magnetic moment $\vec{m}$. For this purpose, the basic physical equation 2.1.3 was used, which comes from the paper "The reinterpretation of the Einstein de Haas experiment[1]".

$$\vec{m} = 2I \cdot \vec{A} \qquad (2.1.3)$$

If equation 2.1.3 is applied to Fig. 3, a current I results for the electron's revolution around the center. The area $\vec{A}$ lies within the orbit through the electron and its vector points in the direction of the resulting magnetic field strength $\vec{H}$.
Fig.3 also shows that the magnetic moment $\vec{m}$ always points to the same pole of the atom. A change in the direction of travel of the electric current I would also change the direction of the velocity vector $\vec{v}$. This leads to the direction of the magnetic moment $\vec{m}$ reversing, but also to the magnetic field strength $\vec{H}$ being aligned in the opposite direction. Equations 2.3.1 and 2.3.2 in combination with Fig. 3 prove this.

$$-\vec{m} = -2\boldsymbol{I} \cdot \vec{A} \qquad (2.3.1)$$

$$-\vec{H} = \vec{\boldsymbol{v}} \times \vec{D} \qquad (2.3.2)$$

This means that the magnetic moment $\vec{m}$ always points in the direction of the same pole. For the Stern Gerlach experiment, this means that the change in direction of the atom's movement would always have to change towards the same pole of the externally applied inhomogeneous magnetic field. But this doesn't happen. If you look at the Stern Gerlach experiment, there is a uniform distribution of the change in direction of movement between the north and south poles of this external magnetic field. This is shown in Fig. 1.

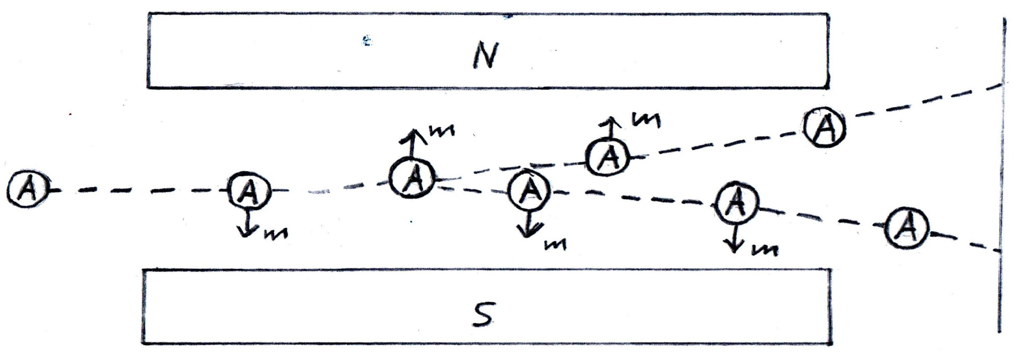

Fig. 1 Stern Gerlach experiment, source: own illustration

The solution to this problem can be found by looking at equation 2.1.3.

$$\vec{m} = 2I \cdot \vec{A} \qquad (2.1.3)$$

Since the change in the electric current I only causes both the magnetic field strength $\vec{\mathrm{H}}$ and the magnetic moment $\vec{m}$ of the atom to reverse, the logical conclusion is that the area vector $\vec{A}$ must reverse so that the atoms have a uniform distribution on the detector depict. This changes the orientation of the magnetic moment $\vec{m}$ of the atom, but not the orientation of the magnetic field strength $\vec{H}$. This is shown by equation 2.3.3.

$$-\vec{m} = 2I \cdot (-\vec{A}) \tag{2.3.3}$$

The resulting conclusion is that there are two types of atoms. One with a negative area vector $-\vec{A}$ and one with a positive area vector $\vec{A}$. In other words, there is an opposite definition of “above” and “below” for the two types of atoms. The question of why this is so is interesting, but should not be the subject of this paper.

3. DISCUSSION

1. Apart from the situation presented in this paper, are there any other ways to maintain the orientation of the magnetic field in equation 2.3.3 with regard to changing the orientation of the magnetic moment?

2. What effects does the facts presented in this paper have on the physical representation of an atom?

3. What is the significance of the fact presented in this paper that the surface vector changes its orientation?

4. What effects does the facts presented in this paper have on the physical area of quantum mechanics? Theories regarding spin and intrinsic angular momentum of the electron may be affected.

5. Are there other areas of physics that are influenced by the facts presented in this paper and if so, which ones and how?

4. CONCLUSION

Atoms have a magnetic moment $\vec{m}$, as proven by both the Einstein de Haas experiment and the Stern Gerlach experiment. The Stern Gerlach experiment also proves that the magnetic moment $\vec{m}$ can be aligned both to the south pole of the atom and to the north pole of the atom. In classical physics this is possible using equation 2.1.3. The equation describes an electric current I that circles an area $\vec{A}$.
Analogous to equation 2.1.1, which describes an electric field strength $\vec{E}$ that rotates and thereby creates a magnetic flux density $\vec{B}$, a magnetic field strength $\vec{H}$ also arises in equation 2.1.2. This magnetic field strength $\vec{H}$ points in the direction of the area vector $\vec{A}$ as in Equation 2.1.3 occurs. This means that the electric current I from equation 2.1.3 is responsible for both the magnetic moment $\vec{m}$ and the resulting magnetic field strength $\vec{H}$. If the direction of movement of the electric current I is changed, not only the direction of the magnetic moment $\vec{m}$ but also the orientation of the magnetic field strength $\vec{H}$ of the atom changes. This in turn means that the vector of the magnetic moment $\vec{m}$ of an atom should always point in the direction of the same magnetic pole. However, the Stern Gerlach experiment proves that the vector of the magnetic moment $\vec{m}$ of atoms can point to both its south pole and its north pole. A look at the distribution pattern of the atoms on the detector reveals that there is an even distribution of atoms between the top and bottom of the detector. In order to align the vector of the magnetic moment $\vec{m}$ to the opposite magnetic pole, a different methodology is required. Equation 2.1.3 reveals that it is the area vector $\vec{A}$ that must undergo a sign change so that the magnetic moment $\vec{m}$ aligns with the opposite pole of the particle. The result is that an atom appears to have a convention that defines an "up" and a "down." However, where the atom gets this convention from is not the subject of this elaboration.

5. CONFLICTS OF INTEREST

The author(s) declare that there is no conflict of interest regarding the publication of this article.

6. PROOF OF FINANCING

There was no financial support in the preparation of this scientific publication.

7. QUELLENVERZEICHNIS

[1] Martin, Andreas: *Die Neuinterpretation des Einstein de Haas Versuches.* In: *vixra.org*, 27. Juli 2023, https://vixra.org/abs/2110.0081, abgerufen am 01.05.2024