Experiments on permanent magnets rotation

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Article

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Abstract

Why does the Earth rotate? What forces are responsible for planetary rotation? In the 17th century, an accurate description of the Earth's rotation was provided via Newtonian mechanics. However, the driving force was not given a mechanistic treatment, and it was merely ascribed to a "push" by God. At present, several theories on planetary rotation remain as hypotheses. Hence, the aim of this study was to obtain experimental evidence on the relationship between planetary (Earth) rotation and magnetic fields. The proposed experimental devices and research methods are based on the characteristics of the kinematic relations between the sun and a planet. A permanent magnet representing the sun is installed on the shaft of a DC motor; a spherical magnet representing the planet is placed at the centre of hollow a sphere that can float on water, ensuring free rotation. Using the above setup, experiments for analysing permanent magnet rotation in a magnetic field and determining the reasons for this rotation were conducted.

Introduction

All astronomical objects in the solar system are known to rotate[1], similar to the Earth[2]. At present, it is impossible to experimentally determine the forces responsible for planetary rotation[3,4,5]. Magnetic fields are among the fundamental fields of nature and exist in the space around satellites, planets, stars, galaxies, currents, moving charges, permanent magnets, and varying electric fields. Although magnetic fields cannot be seen or touched, they can be studied based on their interactions with permanent magnets. The rapid development of modern electromagnetics has led to the emergence of electronic products, such as DC motor speed controllers[6], photoelectric digital tachometers (Non-contact)[7]. Permanent magnets of various shapes, sizes and magnetic materials are widely used in daily life[8,9]. With these developments, now researchers have the necessary tools to further explore magnetism.

Material And Methods

DESIGN OF PERMANENT MAGNET REPRESENTING THE SUN

The permanent magnet representing the sun can be spherical, square, rectangular or cylindrical[10,11]. Permanent magnet that represents the sun, abbreviated as "sun" magnet. Each "sun" magnet was installed on the top of the shaft of each DC motor (DC motor model: ZYTD520, DC-24V, 5000 r/min, Gear-box motor, ZGB37RG, DC 24V, rpm: 650)[12]. The centreline of the shaft passed through the center of mass of each "sun" magnet. The DC motor base was round and made of non-magnetic material. The round surface of the base was perpendicular to the rotation axis of the DC motor, making it stable when the base was placed on a horizontal surface. The speed of the DC motor was controlled using an AC / DC power adapter, and the DC moto speed (stop, slow, fast) varied between 60–650 r/min (AC/DC power adapter model: MXD-24W024, INPUT: AC100-240V 50/60 Hz, OUTPUT: DC 1–24 V 100–1000 mA)[13]. In order to distinguish these "sun" magnets with exactly the same shape, size and magnetic material, they were labeled from "sun"m_1, "sun"m_2, "sun"m_3 to "sun"m_{14}. Every "sun" magnets from "sun"m_3 to "sun"m_{14} has the same shape, size and material grade. The north and south poles of the each "sun" magnet were marked "N" and "S" respectively (See "sun"m_1 in Fig. 1)[14]. The magnetic material grades and magnetic parameters corresponding to the names "sun"m_1, "sun"m_2 and "sun"m_3 are shown in Table 1. The shapes and sizes of "sun"m_1, "sun"m_2 and "sun"m_3 are presented in Table 2.

DESIGN OF MAGNET REPRESENTING THE PLANETS

The permanent magnets representing the planets were Spherical[15,16]. abbreviated as "planet" magnet. Each "planet" magnets was placed at the centre of a hollow spherical object floating on water to ensure free rotation. Alternatively, the "planet" magnets could be directly placed in a round transparent container with a concave bottom or on the palm of the experimenter. For convenient observation and research, the north and south poles of each "planet" magnets were marked with dots in two different colours. A bisected circle perpendicular to the N–S pole axis (such as the equator of Earth) was then drawn on each spherical magnet. The two semicircles of the bisected circle were marked in two different colours. In order to distinguish "planet" magnets with the same size and material grade. They were labeled as "planet"m□, "planet"m□, "planet"m□ and "planet"m□ and distinguish them from the "sun" magnet on DC motors[17,18,19]. "planet"m□ and "planet"m□ have the same size, and material grade. "planet"m□ and "planet"m□ have the same size and material grade. "planet"m□ and "planet"m□ have different size and material grade. During the experiment, each "planet" magnets was independent and could not stick to other magnets (See Fig. 2)[14]. The magnetic material grades and magnetic parameters corresponding to the names "planet"m□, "planet"m□, "planet"m□ and "planet"m□ are shown in Table 1. The sizes of "planet"m□, "planet"m□, "planet"m□ and "planet"m□ are shown in Fig. 2.

TABLE 1 The magnetic parameters corresponding to the names of the "sun" and "planet" magnets

Name	Grade	Br		Hcb(BHC)		Hcj(IHC)		(BH)max	
		MT	KG	KA/m	KOe	KA/m	KOe	Kj/m▯	MGOe
"sun"m_1	N35	1170/1210	11.7/12.1	876/899	11/11.3	≥955	≥12	263/279	33/36
"sun"m_2	N42	1290/1320	12.9/13.2	836/876	10.5/11	≥955	≥12	318/334	40/42
"sun"m_3	Y30	370/400	3.7/4.0	175/210	2.20/2.64	180/220	2.26/2.7	26.0/30.0	3.3/3.8
"planet"m▯	N42	1209/1320	12.9/13.2	836/876	10.5/11	≥955	≥12	318/334	40/42
"planet"m▯	N42	1290/1320	12.9/13.2	836/876	10.5/11	≥955	≥12	318/334	40/42
"planet"m▯	Y30	370/400	3.7/4.0	175/210	2.20/2.64	180/220	2.26/2.7	26.0/30.0	3.3/3.8
"planet"m▯	Y30	370/400	3.7/4.0	175/210	2.20/2.64	180/220	2.26/2.7	26.0/30.0	3.3/3.8

DEVICE FOR OBSERVING THE REASON OF MAGNET ROTATION

The Spherical permanent magnet ("sun"m_1) was used[20]. An arbitrary circle passing through the N and S poles of "sun"m_1 was drawn on the sphere. To divide these semicircles in half, two points, A and B, were selected on the NS and SN semicircles. Therefore, the central angles of arcs NA, NB, SA, and SB arcs were all 90°. Then, two arbitrary arcs were selected, such as NB and SA. The N and S points were set at 0°, whereas points A and B were set at 90°. The subdivisions between 0° and 90° were then marked on arcs SA and NB. The top of the rotating shaft in the DC motor was aligned at any point between 0° and 90° on "sun"m_1; therefore, the centreline of the shaft passed through the center of mass of "sun"m_1 (See "sun"m_1 in Fig. 1)[14].

EXPERIMENTAL SETUPS AND PROCEDURES

First, a spherical "sun"m_1 was installed at the top of the rotating shaft of DC motor. The top of the axis is connected to point (B) on "sun"m_1. The N and S poles of "sun"m_1 were aligned perpendicular to the rotating shaft. The rotation speed of "sun"m_1 was varied between 60 to 650 r/min using a DC motor speed controller[21]. Next, "planet"m▯ was placed inside a hollow spherical object that floated on water. "planet"m▯ was then placed in a round transparent container filled with water. During the experiment, "sun"m_1 and "planet"m▯ were kept away from ferromagnetic objects, and the temperature is below80 ℃. (See Fig. 1)[14].

In experiment A, "planet"m▯ was placed at approximately 10–30 cm from the centre of "sun"m_1. Taking the horizontal plane in the round transparent container, marked magnetic poles and double-coloured circles on "planet"m▯ as the frame of reference. "sun"m_1 was rotated at a speed of 60–180 r/min. Under the action of the rotating torque of "sun"m_1, the behavior of "planet"m▯ floating in a circular transparent container was observed.

In experiment B, with "sun"m_1 as the center, slowly moved the "planet"$m_{\square}$ back and forth at distance of 10–30 cm, keeping it away from or near the "sun"m_1. Then, the speed of "sun"m_1 was repeatedly varied from 60 r/min to a maximum speed 650 r/min. Observed the relationship between the rotation behavior of "planet"$m_{\square}$ and the distance of "sun"m_1, as well as the relationship with the rotational speed of "sun"m_1.

In experiment C, "planet"$m_{\square}$ was placed at 10–30 cm from "sun"m_1. When "sun"m_1 rotated at 60–120 r/min, the rotational speed relationship between "planet"$m_{\square}$ and "sun"m_1 was observed. When the rotational speed of "sun"m_1 exceeded 120 r/min, the rotational speed relationship between "sun"m_1 and "planet"$m_{\square}$ was measured using a photoelectric digital tachometer (Non-contact).

In experiment D, with "sun"m_1 as the center, "planet"$m_{\square}$ was slowly moved away from the "sun"m_1 to farther distances: (1) When the "planet"$m_{\square}$ is placed in every position away from the "sun"m_1. First, let the "sun"m_1 stops rotating, and the "planet"$m_{\square}$ is static. Next, let the "sun"m_1 on the DC motor was rotated in the range 0–120 r/min. Then, the maximum rotation distance (r_1) between the first kind of "sun"m_1 and the "planet"$m_{\square}$ is measured. (2) First, let the "sun"m_1 rotate in the range of 60–120 r/min, the "planet"$m_{\square}$ is rotating. Next, slowly move the "planet"$m_{\square}$ from the position of the first kind maximum rotation distance until the "planet"$m_{\square}$ reaches the farthest rotation position. Then, the maximum rotation distance (r_2) between the second kind of "sun"m_1 and the "planet"$m_{\square}$ is measured. (3) When the rotating "planet"$m_{\square}$ is placed in every different position away from the "sun"m_1. Observed the position change of the "planet"$m_{\square}$ floating on the water surface of the circular container. Based on the above method, "sun"m_1, "sun"m_2 and "sun"m_3 of different shapes, sizes and magnetic material grades are used on the same horizontal plane, and "planet"$m_{\square}$, "planet"$m_{\square}$, "planet"$m_{\square}$ and "planet"$m_{\square}$ are used for permanent magnet rotation. Then, the two kinds of maximum rotation distances (r_1) and (r_2) between each "planet" magnet and each "sun" magnet are measured (avoided using a ferromagnetic ruler for the measurements). The results are presented in Table 2.

In experiment E, 12 permanent magnets with the same shape, size and material grade as the "sun"m_3 are used. When the different magnetic poles of these permanent magnets attract each other, the magnetic pole can spontaneously remain on the same line. "sun"m_4 consists of two magnets, "sun"m_5 consists of three magnets, "sun"m_{14} consists of 12 magnets. From "sun"m_4 to "sun"m_{14}, add one magnet for each "sun" magnet one by one. Then, "planet"$m_{\square}$ and each "sun" magnet from "sun"m_4 to "sun"m_{14} are used for permanent magnet rotation. Measure the two kinds of maximum rotation distances (r_1) and (r_2) between "planet"$m_{\square}$ and each "sun" magnet from "sun"m_4 to "sun"m_{14}. The results are presented in Table 3.

In experiment F, first, with the center of mass of "sun"m_1 as the center of the circle and take a round surface, the round surface is perpendicular to the horizontal plane. On the surface of this circle, slowly move the "planet"m▯ away from the "sun"m_1. Starting from the horizontal plane 0 °, the operation was repeated at angles of 30 °, 60 °, 90 °, 120 °, 150 °, 180 °, 210 °, 240 °, 270 °, 300 °and 330 °, respectively. Then, at each angle listed above, measure the second kind of maximum rotation distance (r_2) between the "planet"m▯ and the "sun"m_1. The results are presented in Table 4. Next, based on the above methods, with the two-color circle on the "planet"m▯ as the frame of reference The rotation direction of "planet"m▯ is observed from different angles and compared with that of "sun"m_1.

In experiment G, the "sun"m_1 was the center, rotating at 60–180 r/min. "planet"m▯ and "planet"m▯ are located on the left and right sides of "sun"m_1. Under the action of "sun"m_1 rotation torque, the "planet"m▯ and "planet"m▯ always keep rotating in the magnetic field. (1) First, the rotating "planet"m▯ is placed at the position of the second kind maximum rotation distance. On the straight line passing through the centre of mass of "sun"m_1 and "planet"m▯, let the rotating "planet"m▯ slowly approach "planet"m▯. Next, place the rotating "planet"m▯ at a different distance from the "sun"m_1. The distance between "planet"m▯ and the "sun"m_1 is 50 cm. The distance between "planet"m▯ and the "sun"m_1 is 30 cm. Then, measure the minimum distance between the front and rear positions of "planet"m▯ and "planet"m▯ that does not affect each other's rotation. Based on the minimum distance between "planet"m▯ and "planet"m▯ that does not affect each other's rotation. The second kind maximum rotation distance between "planet"m▯ or "planet"m▯ and "sun"m_1. Several "planet" magnets identical to "planet"m▯ and "planet"m▯ are arranged in a straight line from far to near. Then, count the number of "planet" magnets. (2) First, the rotating "planet"m▯ is placed at the position of the second kind of maximum rotation distance. On the straight line passing through the centre of mass of "sun"m_1 and "planet"m▯, let the rotating "planet"m▯ approach "planet"m▯ from up, down, left and right directions. Next, place the rotating "planet"m▯ at a different distance from the "sun"m_1. The distance between "planet"m▯ and the "sun"m_1 is 50 cm. The distance between "planet"m▯ and the "sun"m_1 is 30 cm. The distance between "planet"m▯ and the "sun"m_1 is 10 cm. Then, different positions from "planet"m▯ to "sun"m_1, measure the minimum distance between the up, down, left and right positions of "planet"m▯ and "planet"m▯ that does not affect each other's rotation. Based on the minimum distance between "planet"m▯ and "planet"m▯ that does not affect each other's rotation. The second kind maximum rotation distance between "planet"m▯ or "planet"m▯ and "sun"m_1. In each position where "planet"m▯ is placed, with "planet"m▯ as the center, several "planet" magnets are arranged, and the "planet" magnets are the same as "planet"$m_{\square}$ and "planet"$m_{\square}$. Then, count the number of "planet" magnets for each position and the total number of three positions.

In experiment H, based on the maximum rotation distance between of "sun" magnet and "planet" magnets, within the second kind maximum rotation distance of "sun" magnet and "planet" magnet. First, put the undesigned floating "planet"$m_{\square}$ directly into a smooth circular transparent container with a concave bottom. In order to enhance the stability of the rotation of the "planet"$m_{\square}$, round container is filled with water. The "sun"m_1 was the center, rotating at 60 r/min. On the same horizontal plane, the rotating "planet"$m_{\square}$ is placed at different positions away from the "sun"m_1. (1) Observed the change of the angle between the polar direction of "planet"$m_{\square}$ and the floating horizontal plane. (2) Observe the change of the angle between the polar direction of "planet"$m_{\square}$ and the rotation axis. The observation method is as follows: When the rotating "planet"$m_{\square}$ is placed at different positions away from the "sun"m_1. Taking the horizontal plane in the round transparent container, marked magnetic poles and double-coloured circles on "planet"$m_{\square}$ as the frame of reference. Then, observed the changing behavior of both ends of the "planet"$m_{\square}$ magnetic pole.

In experiment I, "planet"$m_{\square}$ was placed on the palm of the hand, and "sun"m_1 was rotated at 60–650 r/min using the DC motor speed controller. The DC motor to which "sun"m_1 was attached and the sphere containing "planet"$m_{\square}$ were held in the left and right hands of the experimenter, respectively. Then, the distance between "sun"m_1 and "planet"$m_{\square}$ was varied between 5 and 30 cm, and the experimenter could feeling the strength of the two different types of magnetic forces between "planet"$m_{\square}$ and "sun"m_1[23,24].

In experiment J, (1) The distance between "planet"$m_{\square}$ and "sun"m_1 was set to 15–30 cm. The top of the rotating shaft of the DC motor was aligned at each point between 0° and 14°, from S to A or N to B, whereas "sun"m_1 was rotated at 60–650 r/min. Taking magnetic pole dots and double-coloured circles marked on "planet"$m_{\square}$ as the frame of reference. The resulting rotation behaviour of "planet"$m_{\square}$ was then recorded (See Fig. 1). (2) The distance between "sun"m_1 and "planet"$m_{\square}$ was set to 15–30 cm, and "sun"m_1 was rotated at 60–180 r/min. The top of the rotating shaft in the DC motor was aligned at points between 15° and 22° from S to A or from N to B. Taking magnetic pole dots and double-coloured circles marked on "planet"$m_{\square}$ as the frame of reference. The resulting rotation behaviour of "planet"$m_{\square}$, and the relationship between the rotating speeds of "sun"m_1 and "planet"$m_{\square}$ were then observed (See Fig. 1). (3) The distance between "sun"m_1 and "planet"$m_{\square}$ was set to 15–30 cm, and "sun"m_1 was rotated at 60–120 r/min. The top of the rotating shaft in the DC motor was aligned at points between 23° and 90° from S to A or from N to B. Taking magnetic pole dots and double-coloured circles marked on "planet"m▯ as the frame of reference. The resulting rotation behaviour of "planet"m▯ was then observed (See Fig. 1).

Experimental Results

Rotation of spherical magnet

"planet"m▯ started to rotate in the magnetic field because of the rotational torque of "sun"m_1[25,26]. Irrespective of where "planet"m▯ was located around "sun"m_1, "planet"m▯ always rotated around the axis passing through its core, similar to the rotation of the Earth[27]. Even when a 2.5-mm-thick iron plate was placed between them, "planet"m▯ continued to rotate owing to the magnetic field. Therefore, place "planet"m▯ could be placed anywhere around "sun"m_1 and observe its rotation behaviour. Furthermore, its rotational axis "wobbled" once around its core during each cycle. This phenomenon is similar to the "Chandler wobble" and "polar wandering" exhibited by the Earth's rotation axis[28,29]. The results of this method show, for permanent magnets with the same magnetic material grade, when the size of the "sun" magnet is greater than or equal to the size of the "planet" magnet. No matter whether the "sun" magnet is a sphere, a cube, a cylinder or a cuboid, as long as the "planet"magnet is a sphere. The "planet"magnet will rotate in the magnetic field under the rotating torque of the "sun" magnet.

Distance and speed of magnet rotation

The results of this method show, when the distance between "planet"m▯ and "sun"m_1 was large, the initial speed of "sun"m_1 was decreased to allow "planet"m▯ to rotate. When the distance between "planet"m▯ and "sun"m_1 was small, "planet"m▯ rotated regardless of the speed of "sun"m_1. For example, when the distance between "planet"m▯ and "sun"m_1 is 30 cm, the initial speed of "sun"m_1 cannot exceed 180 r/min, and the maximum speed cannot exceed 360 r/min; otherwise, "planet"m▯ cannot rotate. When the distance between "planet"m▯ and "sun"m_1 is less than or equal to 10 cm, "planet"m▯ will rotate, regardless of the speed of "sun"m_1.

Synchronous rotation of magnet

The rotational speed of "planet"m▯ was the same as that of "sun"m_1. In each rotation period of "sun"m_1, the S and N poles of "planet"m▯ corresponded to the N and S poles of "sun"m_1, respectively. Therefore, the rotations of "planet"m▯ and "sun"m_1 were synchronous, and their rotational speed were the same[30]. When "sun"m_1 accelerated, decelerated, or stopped rotating, "planet"m▯ accelerated, decelerated, or stopped rotating accordingly.

Maximum rotation distance

The results of this method also show, when the "planet" magnet is in the second kind of maximum rotation distance. No matter what the rotation speed of the "sun" magnet on DC motor is, the static "planet" magnet cannot rotate. The results of this method also show, according to the above method, permanent magnets of different sizes and material grades can be used to represent the planets and the sun. With the "sun" magnet as the center, slowly move the "planet" magnet to farther position, and measure the two kinds maximum rotation distances (r_1) and (r_2) between the "planet" magnet and the "sun" magnet. The results of this method also show, when the rotating "planet" magnet is placed at a different position away from the "sun" magnet, the position of the "planet" magnet floating on the water in the circular container is different. For instance, when the "planet"$m_{□}$ is far away from the "sun"m_1 at the second kind maximum rotation distance, the "planet"$m_{□}$ rotates in the center of the water surface of the circular container. When the "planet"$m_{□}$ and the "sun"m_1 are very close, in the direction of the "sun"m_1, the "planet"$m_{□}$ rotates near the wall of the circular container.

TABLE 2 The maximum rotation distance r_1 and r_2 between the "sun" magnet and "planet" magnet

Name	SCL/DIM.(mm)	n (r/min)	Name	r_1/r_2 (cm)
"sun"m_1	●/DIA 30	0-60/60-120	"planet"m	40/52
"sun"m_1	●/DIA 30	0-60/60-120	"planet"m	40/52
"sun"m_1	●/DIA 30	0-60/60-120	"planet"m	35/42
"sun"m_1	●/DIA 30	0-60/60-120	"planet"m	35/42
"sun"m_2	●/DIA 10	0-60/60-120	"planet"m	14/20
"sun"m_2	●/DIA 10	0-60/60-120	"planet"m	14/20
"sun"m_2	●/DIA 10	0-60/60-120	"planet"m	8/14
"sun"m_2	●/DIA 10	0-60/60-120	"planet"m	8/14
"sun"m_3	■/L.W.H 50·50·25	0-60/60-120	"planet"m	42/60
"sun"m_3	■/L.W.H 50·50·25	0-60/60-120	"planet"m	42/60
"sun"m_3	■/L.W.H 50·50·25	0-60/60-120	"planet"m	36/44
"sun"m_3	■/L.W.H 50·50·25	0-60/60-120	"planet"m	36/44

Number of magnets and rotation distance

The results of this method show, researchers can use permanent magnets of any material grade with the same shape and size and different numbers of permanent magnets to represent the sun. As long as the north and south poles of these permanent magnets can be kept on the same straight line spontaneously. Then, use different numbers of "sun" magnets and same "planet" magnets to investigate the two kinds of maximum rotation distances (r_1) and (r_2) between permanent magnets (When using large-size, high-strength permanent magnets, researchers should pay attention to the damage of the hand and inseparable consequences because the permanent magnets will combine spontaneously in an instant when they are close).

TABLE 3 Maximum rotation distance r_1 and r_2 between different numbers of "sun" magnets and the same "planet" magnet

Name	DIM (mm)	n (r/min)	Name	r_1 / r_2 (cm)
"sun"m_4	L.W.H /50·50·50	60	"planet"m▯	54/72
"sun"m_5	L.W.H /50·50·75	60	"planet"m▯	62/88
"sun"m_6	L.W.H/ 50·50·100	60	"planet"m▯	70/98
"sun"m_7	L.W.H /50·50·125	60	"planet"m▯	76/106
"sun"m_8	L.W.H /50·50·1150	60	"planet"m▯	82/114
"sun"m_9	L.W.H /50·50·175	60	"planet"m▯	78/132
"sun"m_{10}	L.W.H /50·50·200	60	"planet"m▯	86/138
"sun"m_{11}	L.W.H/ 50·50·225	60	"planet"m▯	90/146
"sun"m_{12}	L.W.H /50·50·250	60	"planet"m▯	94/152
"sun"m_{13}	L.W.H /50·50·275	60	"planet"m▯	98/158
"sun"m_{14}	L.W.H /50·50·300	60	"planet"m▯	104/164

Rotation direction and distance of magnet

The results of this method show, permanent magnets of different sizes and material grades can be used to represent the planets and the sun. With "sun" magnet as the center, the maximum rotation distance between the "planet" magnet and the "sun" magnet can be measured in each direction. The rotation direction of "planet"m▯ was different at every angle and distance[31]. However, it was the same for any pair of angles with a difference of 180°. Assume that the radius of the center of mass from "planet"m▯ to "sun"m_1 is 25 cm. the rotation directions of "planet"m▯ were the same at 0° and 180° (opposite to the rotation directions of "sun"m_1), at 60° and 240° (perpendicular to the rotation directions of "sun"m_1), and at 90° and 270° (same as the rotation directions of "sun"m_1).

TABLE 4 The maximum rotation distance of the "planet" magnet centered on the "sun" magnet in the following directions

Name	●	n (r/min)	Name	r_2 (cm)
"sun"m_1	0°	60	"planet"$m_{\square}$	52
"sun"m_1	30°	60	"planet"$m_{\square}$	48
"sun"m_1	60°	60	"planet"$m_{\square}$	40
"sun"m_1	90°	60	"planet"$m_{\square}$	46
"sun"m_1	120°	60	"planet"$m_{\square}$	40
"sun"m_1	150°	60	"planet"$m_{\square}$	48
"sun"m_1	180°	60	"planet"$m_{\square}$	52
"sun"m_1	210°	60	"planet"$m_{\square}$	48
"sun"m_1	240°	60	"planet"$m_{\square}$	40
"sun"m_1	270°	60	"planet"$m_{\square}$	46
"sun"m_1	300°	60	"planet"$m_{\square}$	40
"sun"m_1	330°	60	"planet"$m_{\square}$	48

Rotation of several spherical magnets

The results of this method show: (1) On the straight line passing through the centre of mass of "sun"m_1 and "planet"$m_{\square}$, slowly move "planet"$m_{\square}$ to approach "planet"$m_{\square}$. When the distance between "planet"$m_{\square}$ and "sun"m_1 is 50 cm, the minimum distance between "planet"$m_{\square}$ and "planet"$m_{\square}$ that does not affect each other's rotation is 20cm. When the distance between "planet"$m_{\square}$ and "sun"m_1 is 30 cm, the minimum distance between "planet"$m_{\square}$ and "planet"$m_{\square}$ that does not affect each other's rotation is 15cm. On any ray with the centre of mass of the "sun"m_1 as the vertex, three "planet" magnets can be arranged from far to near. Which are exactly the same as "planet"$m_{\square}$ and "planet"$m_{\square}$. (2) the rotating "planet"$m_{\square}$ approach "planet"$m_{\square}$ from up, down, left and right directions. When the distance between "planet"$m_{\square}$ and "sun"m_1 is 50 cm, the minimum distance between "planet"$m_{\square}$ and "planet"$m_{\square}$ that does not affect each other's rotation is 20cm. Six "planet" magnets can be arranged around "planet"$m_{\square}$. When the distance between "planet"$m_{\square}$ and "sun"m_1 is 30 cm, the minimum distance between "planet"$m_{\square}$ and "planet"$m_{\square}$ that does not affect each other's rotation is 15cm. Six "planet" magnets can be arranged around "planet"$m_{\square}$. When the distance between "planet"$m_{\square}$ and "sun"m_1 is 10 cm, the minimum distance between "planet"$m_{\square}$ and "planet"$m_{\square}$ that does not affect each others rotation is 6 cm. Six "planet" magnets can be arranged around "planet"$m_{\square}$. In the three positions above, totally 21 "planet" magnets are arranged. The results of this method show, permanent magnets of different sizes and material grades can be used to represent "planet" magnets and "sun" magnet. On any ray with the center of mass of the "sun" magnet as its apex, different numbers of "planet" magnets can be placed, and different numbers of "planet" magnets can be placed around the "sun" magnet[32].

Distance and polar direction

The results of this method show, when the distance between "planet"$m_{\square}$ and "sun"m_1 changed, the angle between the two ends of the magnetic pole of "planet"$m_{\square}$ and the horizontal plane changed with respect to the centre of its own sphere as the vertex[33]. At every point from "planet"$m_{\square}$ to "sun"m_1, the angle between the polar direction of "planet"$m_{\square}$ and the floating horizontal plane has a fixed range. Within this fixed angle range, the two ends of the magnetic poles of the "planet"$m_{\square}$ will periodically and spontaneously shift. For example, when the "planet"$m_{\square}$ and the "sun"m_1 are very close to 5-10 cm. During the shift of magnetic pole, the angle between the polar direction of "planet"$m_{\square}$ and the water surface is sometimes almost parallel. The double-coloured circles on "planet"$m_{\square}$ is nearly perpendicular to the water surface. When the "planet"$m_{\square}$ is in the position of the second kind of maximum rotation distance, the distance between "planet"$m_{\square}$ and "sun"m_1 is 40 cm. During the shift of magnetic pole, the angle between the polar direction of "planet"$m_{\square}$ and the water surface is sometimes almost vertical. The double-coloured circles on "planet"$m_{\square}$ is nearly parallel to the water surface. The results of this method also show, with the change of the distance between the "sun" magnet and the "planet" magnet, the angle between the polar direction of the planet magnet and the water surface changes. This has nothing to do with the maximum rotation distance between "sun" magnets and "planet" magnets of different sizes and material grade. (2) When the distance between "planet"$m_{\square}$ and "sun"m_1 changed, the rotation axis of the "planet"$m_{\square}$ is always perpendicular to the water surface. The range of angle change between the polar direction of "planet"$m_{\square}$ and the water surface is always on the left and right of the axis of rotation. When the angle between the polar direction of the "planet"$m_{\square}$ and the water surface changes, the angle between the polar direction of the "planet"$m_{\square}$ and the rotation axis changes at the same time. It is opposite to the angle change between the polar direction of the "planet"$m_{\square}$ and the water surface. For example, when the "planet"$m_{\square}$ and the "sun"m_1 are very close to 5-10 cm. During the shift of magnetic pole, the angle between the polar direction of "planet"$m_{\square}$ and its axis of rotation is sometimes nearly vertical. When the "planet"$m_{\square}$ is in the position of the second kind of maximum rotation distance, the distance between "planet"$m_{\square}$ and "sun"m_1 is 40 cm. During the shift of magnetic pole, the angle between the polar direction of "planet"$m_{\square}$ and its axis of rotation is sometimes nearly coincide. The rotation axis and polar direction are perpendicular to the water surface at the same time. The results of this method also show, with the "sun" magnet as the center, the rotating "planet" magnet can be placed in any direction away from the "sun" magnet. Observed the change of the angle between the polar direction of "planet" magnet and the floating horizontal plane, and the change of the angle between the polar direction of "planet" magnet and the rotation axis. The results of this method also show, when the "sun" magnet rotates at a constant speed of 60 r/min, the rotation of the "planet" magnet and the synchronous rotation of the "sun" magnet are uneven speeds. The "planet" magnet pauses for a moment in each rotation cycle, and then continues to rotate. In addition, when the angle between the two ends of the magnetic pole of "planet"$m_{\square}$ and the horizontal plane changed with respect to the centre of its own sphere as the vertex. On the sphere of "planet"$m_{\square}$, all parts except the center of the sphere will change, including the axis of rotation. The reason why the experimenter observes that the rotation axis of the "planet"$m_{\square}$ is always perpendicular to the water surface is because there is no mark on the rotation axis, which will give the experimenter an illusion that the position of the rotation axis has not changed. The method of marking the position of the rotation axis on the "planet"$m_{\square}$ sphere is as follows: when the rotating "planet"$m_{\square}$ is placed at any position far away from the "sun"m_1, use a colored paint pen to align the tip of the pen with the axis of rotation and mark the axis of rotation. Then, use the mark on the rotation axis as a frame of reference to observe the behavior of the "planet"$m_{\square}$ rotation axis.

Feeling the rotational forces

The experimenter was familiar with the strength of the attractive force between "planet"$m_{\square}$ and "sun"m_1. Simultaneously, the experimenter was able to feeling the strength of the rotation force between "sun"m_1 and "planet"$m_{\square}$ by hand[34,35]. The rotation force strength of "planet"$m_{\square}$ increases with the decrease of the distance between "sun"m_1 and "planet"$m_{\square}$, and decreases with the increase of the distance between "sun"m_1 and "planet"$m_{\square}$. In addition, experimenters do not need to design the "planet" magnet to float, but directly hold the "planet" magnet in the palm of the hand to feeling the attractive force and rotation force between the "planet" magnet and the "sun" magnet. When researchers use different sizes and material grades of "sun" magnets and "planet" magnets to research the rotation force. The size and magnetic field strength of "sun" magnet and "planet" magnet should not be too large at the same time. Otherwise, when the distance between the "sun" magnet and the "planet" magnet is relatively close, the hands can not control the "sun" magnet and the "planet" magnet, they will stick together instantly, and even cause damage to the hands and apparatus.

Cause of magnet rotation

(1) "planet"$m_{\square}$ did not rotate when the top of the rotating shaft of the DC motor was aligned at a point between 0°–14°, from S to A or N to B. This occurred regardless of the orientation of "planet"$m_{\square}$ relative to "sun"m_1, rotational speed of "sun"m_1, and distance between "sun"m_1 and "planet"$m_{\square}$. (2) "planet"$m_{\square}$ rotated around its core in an oscillatory manner with a large amplitude when the top of the rotating shaft of the DC motor was aligned at a point between 15°–22°, from S to A or N to B. The rotational speed of "planet"$m_{\square}$ was slower than that of "sun"m_1, as "planet"$m_{\square}$ only completed one cycle for every three–five cycles completed by "sun"m_1. The rotational motion of "planet"$m_{\square}$ was similar to the "astronomical nutation" exhibited by the Earths rotational axis[36]. (3) The rotational speed of "planet"$m_{\square}$ was equal to that of "sun"m_1 when the top of the rotating shaft of the DC motor was aligned at a point between 23°–90°, from S to A or N to B, regardless of the orientation of "planet"$m_{\square}$ relative to "sun"m_1. Furthermore, the rotations of "planet"$m_{\square}$ and "sun"m_1 were synchronised.

Conclusions And Future Outlook

Based on the results obtained using the designed apparatus and the aforementioned experimental procedures, the following conclusions are presented:

(1) With the rotating "sun" magnet as the center, the following rotational behaviour of the "planet" magnet can be observed: "planet" magnet rotates in the magnetic field under the rotating torque of the "sun" magnet; The rotation of the "planet" magnet depends on the rotational speed of the "sun" magnet and the distance between the "planet" magnet and the "sun" magnet; The synchronous rotation of the "planet" magnet and the "sun" magnet; By changing the space position of the "planet" magnet centered on the "sun" magnet, the rotation direction of the "planet" magnet is changed; By changing the distance between the "planet" magnet and the "sun" magnet, the magnetic pole direction of the "planet" magnet is changed; Several "planet" magnets placed around the "sun" magnet rotate; The maximum rotation distance (r_1) and (r_2) between the "planet" magnet and the "sun" magnet; The minimum distance between the "planet" magnet and the "planet" magnet does not affect the rotation of each other; By changing the connection point between the top of the DC motor shaft and the 0°−90° angle on the spherical "sun" magnet, the "planet" magnet can be rotated or its rotation can be stopped, and leads to a change in the rotation speed of the "planet" magnet and the "sun" magnet; It can help researchers to observe and identify the different magnetic forces, namely the attractive and rotating forces between the magnets. This contributed to the comprehension of the magnetic phenomena in physical electromagnetics discussed in textbooks. This

helps us to further understand the magnetic field force, and provide experimental basis for further improving the efficiency of magnetic energy utilization and establishing mathematical models.

(2) This research has promoted the development of apparatuses for proving the relationship between the sun and planets, and established experimental methods for further studying the relationship between the rotation of permanent magnets of different shapes, sizes and magnetic material and the magnetic field. In addition, this research provides an experimental basis to further investigate the relationship between planetary rotations (e.g., Earth's rotation) and magnetic fields. The results of this research will help researchers to further explore the causes of earth's rotation and unravel the magical mystery of the earth's rotation in the near future.

In future, this research will be further extended to research the methods and procedures that are required for the observation of permanent magnet orbital revolution experiment.

Declarations

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Conflict of Interest: here are no conflicts of interest to declare.

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Figures

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Figure 1

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Supplementary Files

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- FIG.2Designofsphericalpermanentmagnetrepresentingtheplanet.xls
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