VNU. JOURNAL OF SCIENCE, Mathematics - Physics, T.XX, $N_0$3AP, 2004

A TURBULENT TOROIDAL MODEL AND SELF-EXCITING DYNAMO PROCESS

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Abstract: The paper present a turbulent toroidal model of conductive fluid in magnetic field. On the basic of this model, the exisitence of a self-exciting dynamo process has been demonstrated. This process is fundamental for the theory of origin of the Earth's, the Sun's and sunspots' magnetic field. The instrument has been set-up. The testing result with this instrument has confirmed this theory.

1. Introduction

In 1954, Einstein commented that: On the picture of the modern physics there are two most conspicuous gaps those are the magnetic field of the Earth and Cosmic rays [1]. There are many theories of origin of magnetic field of the Earth those have been given. But today, only the magnetohydrodynamic dynamo theory was being developed[2] .In fact, the mechanism that produces Earth's magnetic field is only vaguely understood[3]. We have considered a turbulent toroidal model, the existence of a self-exciting dynamo process has been demonstrated.

2. Turbulent toroidal model and self-exciting dynamo process

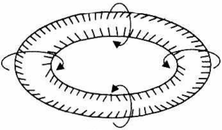

Fig. 1

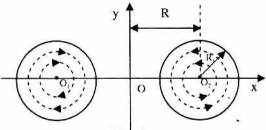

Fig. 2

Suppose there is a turbulent toroid in liquid (fig 1). In the centre of the turbulent tube containing turbulent lines, in wich the tangent at each position is rot$\vec{v}$, where $\vec{v}$ is turbulent velocity of the liquid. Plane xoy cuts the tube into two circles with radius R_1, and O is symmetry centre(fig 2). In the turbulent tube, the liquid moves turbulently and its streamlines are showed by dotted line. At O1, vector rot$\vec{v}$ goes into the paper, at O2 vector rot$\vec{v}$ goes out of the paper. An equal magnetic field B parallel to axis y passes through the turbulent toroid. If the liquid is conducting and resistivity is ρ, due to the motion of the liquid, magnetic field lines are deformed and the neutral plane rotates an angle θ_0 (fig 3). We separate the surface layer from the turbulent toroid with the thickness dx, then we have an empty turbulent tube. Plane xoy cuts this tube into two rings (fig 4). We show a circle of liquid in the empty turbulent toroid on plane xoz, it forms a circle with radius R (θ). The section of the liquid circle dA=dx.dy. When the liquid in the turbulent toroid moves, this circle of liquid moves, too. We can see that the liquid circle moves according to positions 1→ 2 → 3 → 4, the liquid circle area decreases. In contrast, from 4→5→6→1 it expands. When the liquid circle area changes, magnetic flux varies, due to law of induction, we obtain: induced emf $E = -d\phi/dt$ where $\phi = BS\cos\theta_0$; S is the liquid circle area ($S=\pi R^2(\theta)$). Induced emf E will create induced current in that liquid circle.

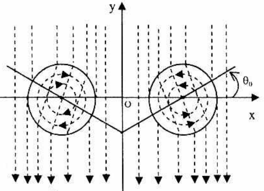

Fig. 3

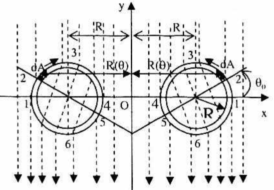

Fig. 4

The average induced current I_{t1}, when the liquid circle moves from 2→3→4→5:

$$I_{t1} = \frac{\int_0^{t_1} I dt}{t_1} = \frac{\int_0^{t_1} \frac{E}{\Omega_{t1}} dt}{t_1} = \frac{-\int_0^{t_1} \frac{1}{\Omega_{t1}} \frac{d\phi}{dt} dt}{t_1} = \frac{\Delta\phi}{\Omega_{t1}} \quad (1)$$

where t_1 is moving time from 2→3→4→5; Ω_{t1} is average resistance of the liquid circle in this place. Similar to when the liquid circle moves from 5→6→1→2, the average induced current in the liquid circle is.

$$I_{t2} = \frac{-\int_0^{t_2} \frac{1}{\Omega_{t2}} \frac{d\phi}{dt}}{t_2} = -\frac{\Delta\phi}{\Omega_{t2} t_2} \quad (2)$$

where t_2 is mouving time from 5→6→1→2; Ω_{t2} is average resistance of the liquid circle in this place. Because I_{t1} and I_{t2} are retrograde, as a result the value of (1) and the value of (2) are retrograde. I_{t1} is the current with tendency creating the magnetic field that has the same trend as the initial magnetisc field, where I_{t2} is in contrast. We form a ratio between I_{t1} and I_{t2} (ignore the sign):

$$\frac{I_{t1}}{I_{t2}} = \frac{\Delta\phi}{\Omega_{t1} t_1} / \frac{\Delta\phi}{\Omega_{t2} t_2} = \frac{\Omega_{t2} t_2}{\Omega_{t1} t_1} \quad (3)$$

The average resistance during the period the liquid circle moves from 2→3→4→5 is: $\Omega_{t1} = 2\pi\rho R_{t1}(\theta)/dA$, where $R_{t1}(\theta)$ is average radius of the liquid circle during the time it moves from 2→3→4→5. According to average theorem in analytic:

$$R_{t1}(\theta)=\frac{\int_{2}^{3}R(\theta)dy+\int_{3}^{5}R(\theta)(-dy)}{(R_1-R_1\sin\theta_0)+(R_1+R_1\sin\theta_0)} \tag{4}$$

where R_1 is radius of rings (fig 4); $R(\theta) = R + R_1\cos(\theta)$: the image of R_1 in axis y is $R_1\sin(\theta)$ there fore $dy = R_1\cos(\theta)d\theta$. From fig 4, we can see that integral from 2 to 3 is integral from θ_0 to 90^0 and integral from 3 to 5 is the one from 90^0 to$180^0 + \theta_0$, the result (4) is:

$$R_{t1}(\theta)=\frac{\int_{\theta_0}^{90}(R+R_1\cos\theta)R_1\cos\theta d\theta+\int_{90}^{180+\theta_0}(R+R_1\cos\theta)(-R_1\cos\theta)d\theta}{2R_1}$$

$$\Rightarrow R_{t1}(\theta)=R-R_1\left(\frac{1}{2}\theta_0+\frac{1}{4}\sin 2\theta_0\right) \tag{5}$$

$$\Omega_{t1}=\frac{2\pi\rho}{dA}\cdot\left[R-R_1\left(\frac{1}{2}\theta_0+\frac{1}{4}\sin 2\theta_0\right)\right] \tag{6}$$

similar to that, we compute Ω_{t2} and finally (3) becomes:

$$\frac{I_{t1}}{I_{t2}}=\left[\frac{R+R_1\left(\frac{1}{2}\theta_0+\frac{1}{4}\sin 2\theta_0\right)}{R-R_1\left(\frac{1}{2}\theta_0+\frac{1}{4}\sin 2\theta_0\right)}\right]^2 \tag{7}$$

we find that (7) is equal to 1 (unit), when $R_1 = 0$ or $\theta_0 = 0$, it means that I_{t1}, the electrical current that makes the initial magnetic field increase is always harder than the current making the initial magnetic field decrease. That is the mechanism of self-exciting dynamo process. We come to conclusion : if in conducting liquid there is a turbulent toroid and magnetic field passing through it, two induced currents of retrograde trend will appear. The current making the initial magnetic field increase is always harder than the one making it decrease, as a result the total magnetic field increases, this process only stops when energy mechanical of the turbulent toroid and electrical magnetic energy are equal. Applying the result above we are able to explain origin of the magnetic field of the Earth and the Sun.

3. Summary

The existance of self-exciting dynamo process in turbulent toroid has been proved. This is foundation to build new theory of origin of the magnetic field of the Earth, the Sun and sunspots. The instrument has been created to inspect theory. The result of the experiment has helped to affirm this new theory.

References

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3. David Halliday, Robert Resnick, Jearl Walker. *Fundamentals of Physics*, John Wiley & Sons 2001.