Aharonov–Bohm effect in CRT experiment

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Nearly two years ago I proposed a CRT experiment to test the magnetic field of a solenoid, see Non-Lorentzian Magnetic force and Aharonov-Bohm effect in CRT, Blogspot, Word published June-27-2013. Since its consequence is great (see Consequences of macroscopic Aharonov-Bohm effect, Blogspot, word), I thought glory-searching physicists would rush on this simple experiment. But until now no one has dared to take the trophy and I have finally decided to carry it out myself. The result is as I predicted.

1. Aharonov–Bohm effect

When a solenoid is inserted between 2 interfering electron beams (see Figure 1), the interference pattern is affected despite that the magnetic field is zero. Here is a Mathematical simulation of Aharonov–Bohm effect. Since the electrons are not deflected by magnetic force, this effect is explained as a quantum phase shift of electron wave by the magnetic potential in space.

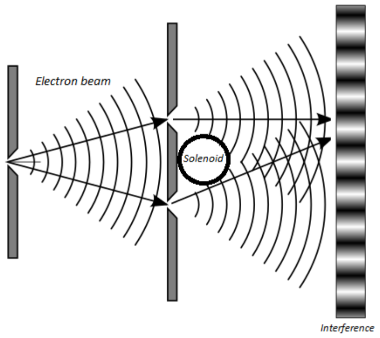

Figure 1

2. CRT experiment

I have discovered that a tensor magnetic field existed around a solenoid and was responsible for the shift of the interference pattern. To verify this explanation, I did this experiment using a long direct-current-carrying solenoid and a cathode ray tube (CRT) (see Figure 2). As result the impact spot on the screen shifted, proving that the electron beam is bent by a magnetic field (see Figure 3).

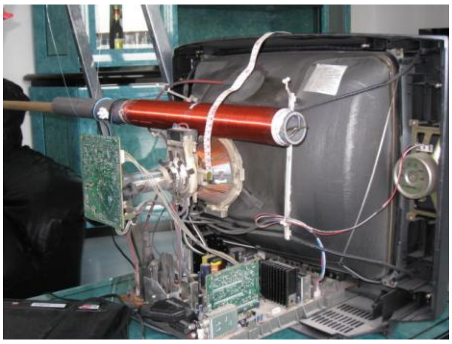

Figure 2

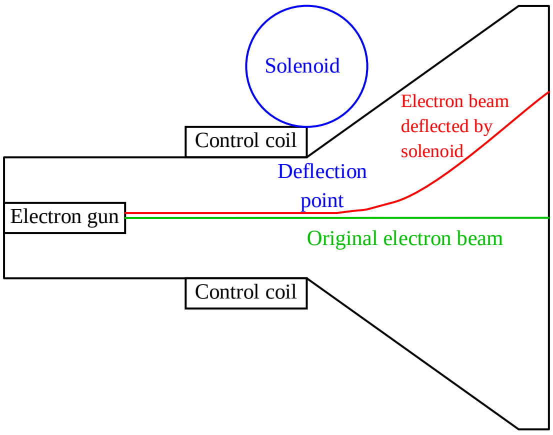

Figure 3

The video of this experiment is on Youtube: https://youtu.be/DXu88IreBj4

Sequence by sequence explanation of the video of the experiment

1. The solenoid is sufficiently long to insure that the magnetic field around the center is zero.
2. The coil's wire is tightly wound so that the magnetic field is totally confined in the interior and does not leak to the exterior.
3. The cathode ray tube of this CRT TV set provides the electron beam for the experiment.
4. The image on the screen is formed by the spots of electron impacts. If the solenoid exerts a magnetic force on the electrons, this image will shift in consequence.
5. Preliminary test of the magnetic field of the solenoid. I approach a suspended iron bolt to the solenoid's end; the bolt sticks to it signaling strong magnetic field there.
6. A light bulb is connected to the solenoid and its light signals current in the solenoid. But the bolt is not attracted within a large region around the solenoid's center despite the light. So, the magnetic field is well zero in this region, in good agreement with the classical magnetic theory.
7. First test of the solenoid's action on electrons. The electron speed is very high near the control coil of the cathode ray tube. The solenoid is placed there to get strong deflection (see Figure 2).
8. The distance between the center of the solenoid and the electron beam is 90 mm.
9. When current flows in the solenoid, the image on the screen immediately shifts up.
10. When the solenoid is vertical the image shifts sideway. Clearly, it is the solenoid's magnetic field that shifts the image.
11. Sketch of the working principle of this experiment: the deflection of electron trajectory by the magnetic field of the solenoid.
12. In order to get still closer to the electron beam, the solenoid is placed directly on the neck of the cathode ray tube. The solenoid's wire is now less than 20 mm from the electron beam.
13. The electron beam is so close to the solenoid's center that the two ends of the solenoid have no influence.
14. In this case the image still shifts, showing the electron beam is bent by the solenoid center's strong magnetic field and breaking the classical prediction that this field is zero.
15. The magnetic field inside the solenoid is strong and has opposite direction. We test this field by placing one end of the solenoid beside the screen and, the image shifts in the opposite direction. But the amplitude of the shift is not big. We conclude that the magnetic force in this case is of the same order than that of the outside magnetic field.
16. The magnetic field emerging from the end weakens rapidly with distance. At 140 mm the magnetic field is as weak as the classical prediction in the central region. By placing one end at 140 mm from the screen, we see that the shift amplitude is much smaller than that caused by the central region. We conclude that the tensor magnetic field outside the solenoid creates strong force on traveling electron.
17. When the solenoid is near the screen, the deflection point of the trajectory is close to the impact point.
18. In consequence, the shift amplitude is smaller than in sequence 9 where the deflection point is at the beginning of the trajectory.
19. When the current is reversed the magnetic field is reversed and the image shifts down.
20. When the solenoid is located after the impact point, for example in front of the screen, the image still shifts, but the amplitude is much smaller. This is an indication of the range of influence of the magnetic field outside the solenoid.

3. Parameters of the solenoid:

Length: 360 mm
Mean diameter: 43 mm
Wire's diameter: 0.5 mm
Number of coil layers: 6
Total number of turns: 3 860
Current intensity: 5 A
Linear density of current: 51 000 A/m

4. Comments

The shift of image on the TV screen cannot be explained by phase shifting. The only possible explanation is that the electrons traveling in the tensor magnetic field are significantly deflected by a force and the pattern of the impact spots is displaced, that is, the image shifts. This experiment, in sharp contraction with the classical magnetic theory's prediction, demonstrates the existence and intensity of the tensor magnetic field.

This magnetic force can also explain the shift of interference pattern of Aharonov–Bohm effect. However it does not rule out the phase-shift explanation. For doing so, a precise measure of the shift and a comparison with theoretical prediction must be done.

This experiment shows that the magnetic field outside the solenoid is not zero, proving experimentally the fail of the classical magnetic theory and the success of my theory. For more details please read Macroscopic Aharonov–Bohm effect experiment and theory, pdf, word.

5. About Ampere's law

Another consequence of this experiment is that Ampere's law is put into question. We use Ampere's law to compute the value of magnetic field inside a solenoid, $\mathbf{B}_a$ in Figure 4. Classically, $\mathbf{B}_a=\mu_0 J$ because $\mathbf{B}_b=0$. Now, $\mathbf{B}_b$ is shown to be non-zero, what is the value of $\mathbf{B}_a$ then? And what is the value of $\mathbf{B}_c$ inside a toroidal coil when $\mathbf{B}_d$ is no longer zero?

The solution lies on the tensor magnetic field theory that I propose. This is important for controlled nuclear fusion because Tokamak is a toroidal coil and plasma is charged particles that react to tensor magnetic field. Big progress in fusion reactor could be done if the magnetic field inside a toroidal coil is computed using tensor magnetic field theory. See Unknown properties of magnetic force and Lorentz force law, Blogspot, word.

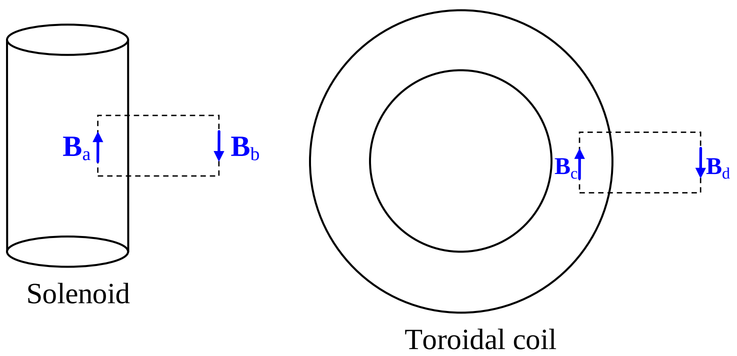

Figure 4