The Electric AB Effect ➡ Violation of Energy Conservation

THE EXPERIMENT

t_1 Two pairs of large parallel plates which are made of an insulating material, are covered uniformly with positive and negative charge, respectively. The distance between the plates of each pair is infinitesimal. Two electronic sub-packets (represented by the white circles) move from left to right towards the plates' X-region.

t_2 When the electronic subpackets are at the plates' region and quite far from the plates' edges, the 2 positively charged plates move adiabatically, as shown.

t_3 Later, when the electronic sub-packets are still quite far from the plates' right hand side, the positively charged plates return to their original position. After leaving the plates' region, the sub-packets interfere on the screen S. All motions are quite slow and the adiabatic approximation holds. This interference pattern is compared to that which is obtained in a null experiment where the plates do not move.

AB Claims

1. The 2 subpackets move in a field-free region.
2. During the time interval $[t_2, t_3]$, the upper subpacket moves in a null potential whereas the lower subpacket moves in a nonvanishing potential.
3. The electronic subpackets make a negligible perturbation that does not affect the physical state of the plates [1].
4. The previous point justifies the single particle treatment presented in the first AB paper [2].
5. Relying on 1-4, one predicts that the 2 interference patterns are different.

[1] Y. Aharonov and D. Bohm, Phys. Rev. 121, 1511 (1961). (See section 3.)
[2] Y. Aharonov and D. Bohm, Phys. Rev. 115, 485 (1959).

Energy Nonconservation

A counter-example proves that at least one of the AB claims is incorrect. Let us make the following small changes in the experiment: The plates return to their original position not at t_3 but much later, when the sub-packets are very far from the plates' region; the screen S is removed; a perpendicular magnetic field B (a part of the magnetic field region is shown on fig. 2) directs the subpackets to their original position on the left hand side of the plates and the process is repeated.

In the modified experiment the upper subpacket is in a null potential at t_2. It moves in a magnetic field and goes back to the plates' left hand side where the potential vanishes. Therefore, it maintains its original kinetic energy. The lower electronic subpacket is ejected by the negative potential, which holds between the two pairs of plates after t_2 and at t_4 it acquires an additional kinetic energy. Thus, the 2 subpackets are split by the magnetic field. The more energetic subpacket enters a region where its additional kinetic energy is removed. Later, this sub-packet is directed to the left hand side by a magnetic field.

This counter-example proves that if AB's claims 1-5 hold then a closed system violates energy conservation [3].

[3] E. Comay, Phys. Lett. **A120**, 196 (1987).

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