Rapid Communication

# Flux Quantization Validates Electromagnetic Induction in the Photoelectric Effect

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*Abstract*
This short communication is a supplement to the article Radio Waves – Part III The Photoelectric Effect in which I advanced the hypothesis that the photoelectric effect can be explained as an effect of electromagnetic induction occurring at the surface of the illuminated metal.
A striking support for the validity of this hypothesis has been discovered recently by the present author in the quantization of the magnetic flux observed experimentally more than 50 years ago.

## Introduction

In the article[1] Radio Waves – Part III The Photoelectric Effect (Explaining the Photoelectric Effect as an Effect of Electromagnetic Induction) I criticized Einstein's erroneous idea that *only* light quanta ("photons") can explain the laws of the photoelectric effect and I brought evidence that the wave theory of light composed of an oscillating magnetic field serves the purpose very well.
The discussion of Faraday's effect of electromagnetic induction at pages 19-21 of the same article[1] reached the necessity of performing an experiment which could settle the

1. Ionel DINU, *Radio Waves – Part III The Photoelectric Effect (Explaining the Photoelectric Effect as an Effect of Electromagnetic Induction)*, General Science Journal (http://gsjournal.net/Science-Journals/Essays/View/4961) or viXra (http://vixra.org/pdf/1306.0220v3.pdf).

issue of whether a magnet moving faster through a coil will cause
**either**
- the number N of moving electrons to increase - variant (a)
**or**
- the speed v of electrons to increase - variant (b).

In variant (a) a stronger magnet moving at the same rate will cause the electrons to move *faster*, in variant (b) it will cause *more* electrons to move at the same speed.

In the article[1] (at p.21) this *experimentum crucis* was not discussed further because the author had no knowledge of such experiment having ever been performed; consequently variant (b) was chosen as it was the one consistent with the explanation of the photoelectric effect as an effect of electromagnetic induction.

However, low temperature physics experiments with superconductors seem to offer the basis for accepting variant (b) and therefore fill the gap of the *experimentum crucis* referred to above.

## Flux quantization in superconducting cylinders

The effect of magnetic flux quantization discovered[2,3] in superconducting materials 1961 provides the needed support for the fact that the magnetic field of a given strength acts on a discrete number of electrons, which is consistent with variant (b) mentioned in the introduction. Since this is true for magnetic fields constant in time, it will be valid also for time-varying magnetic fields such as those used in electromagnetic induction.

The experiments in which magnetic flux quantization was observed used cylinders (both solid and hollow) which carried persistent electric currents that were induced through the cooling of the cylinders into their superconducting state in a constant external magnetic field or by electromagnetic induction.

It was observed that the magnetic flux $\Phi$ due to the persistent electric current flowing in the superconducting cylinder did not increase linearly with the external magnetic field but in steps corresponding to an electric current formed by *a pair of electrons* giving

$$\Phi = n \cdot \frac{h}{2e}$$

This *pair of electrons* is also known as *Cooper pair* although in what persistent superconducting currents are concerned the original theory of Leon Cooper is not necessarily relevant.

See below the results of these important experiments[4].

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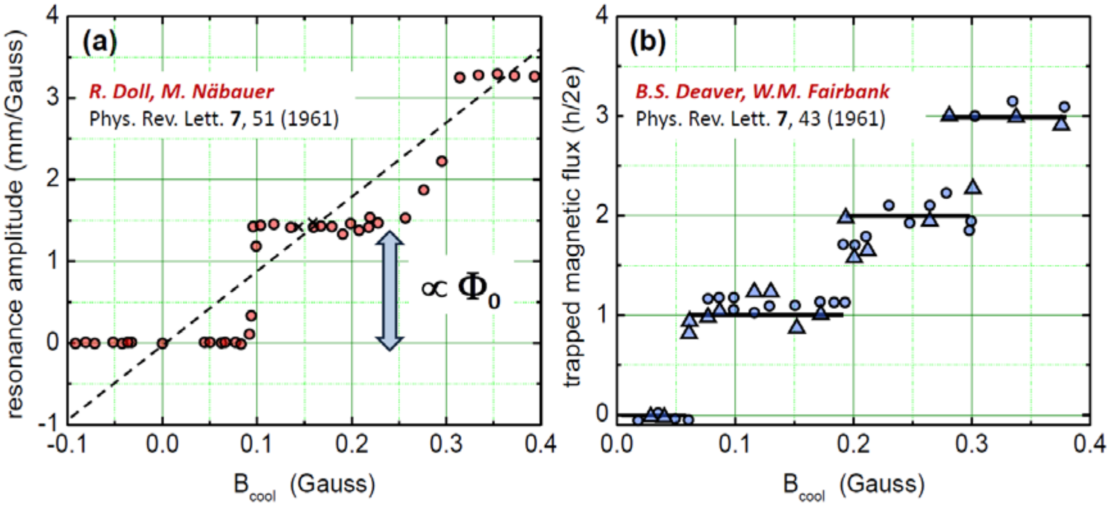
2. B.S. Deaver , W.M. Fairbank, Phys. Rev. Lett. **7**, 43 (1961)
3. R. Doll, M. Nabauer, Phys. Rev. Lett. **7**, 51 (1961)
4. R. Gross, A. Marks and F. Deppe, Walther-Meissner-Institut (2001-2013)




More on these experiments and on phenomena occurring in superconductors can be found in references 5, 6, 7 and others.

Thus magnetic flux quantization comes to support the statement made in the article[1] (p.21) that
"The fact that the number of electrons N caused to move in electromagnetic induction increases with the strength B of the magnet, points to the conclusion that B and N might be proportional: $B = N \cdot b$, where b would correspond to the minimum magnetic field strength necessary to cause an electron to move (I will call b teslon). "

The above quote points then to the conclusion that what I have called teslon is in fact the quantity $\frac{h}{2e}$ called *fluxoid* in the mainstream literature[6].

The fact that in the photoelectric effect we observe only one electron ejected from the metal is due to the other electron of the *pair* (*Cooper pair*) moving in opposite direction: from the study of the electric current induced at the illuminated surface of the metal by the time-varying magnetic field of the light wave it can be seen that while one electron in the metal moves towards the surface to be ejected the other moves deeper into the metal away from the surface.

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5. A.W.B. Taylor, *Superconductivity*, Wykeham Publications (London) Ltd. (1970), p. 31-34
6. Mark W. Zemansky, *Heat and Thermodynamics*, 5th Edition, McGraw-Hill Book Company (1968), p. 553-554.
7. Ernest A. Lynton, *Superconductivity*, 2nd Edition, London: Methuen & Co., Ltd (1964), p.32-33