

# The Two in the Flux Quantum Is Neither a Dimension nor an Exponent but a Count of Carriers

— One More Distinct Root for the Twos Called Over in Paper 157 — And This Two Alone Was Settled by Measurement, Not by Theory — [Paper 270]

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— *From thinking to syncing.* —

## Abstract

Paper 157 called over the twos appearing across this series. This paper asks whether the two standing in the denominator of the flux quantum shares a root with any of them—the answer is with none of them. It is neither a dimension, nor an exponent, nor a factor—it is a count of what carries the charge. No new mathematical theorem and no new law is claimed. First, set the two candidates out in numbers. If the carrier is one electron,  $h/e = 4.135667697 \times 10^{-15}$  Wb; if it is two,  $h/2e = 2.067833848 \times 10^{-15}$  Wb (Section 2). Second, this is the core of the paper. Measurement gives the second—two experiments settled it independently in 1961 (Section 3). Third, so this two did not come out of the theory. That the ratio is 2.0 follows from the expressions, and which of them is true is not settled by them (Section 3). Fourth, it has now moved to the side of definition. Since the SI revision of 2019,  $h$  and  $e$  are exact, so  $\Phi_0$  is exact too (Section 4). Fifth, the same two appears in another constant. The Josephson constant is  $K_J = 2e/h = 483597.8484170$  GHz/V—while the von Klitzing constant  $R_K = h/e^2 = 25812.807459 \Omega$  carries no such two (Section 5). Sixth, that difference is the separator. Flux quantisation is carried by a pair, so a two stands; the quantum Hall effect counts one at a time, so none does (Section 5).

Scope of this paper (scope note): No new mathematical theorem and no new law is claimed—the flux quantum  $h/2e$ , the Josephson constant, the von Klitzing constant and the existence of Cooper pairs are all standard. No theory of superconductivity is built—what is used is two divisions and one ratio. BCS theory is not treated—why electrons pair is not treated at all. What is examined is only in which numbers the fact of pairing appears. Symmetry breaking is not discussed—Paper 175 showed that symmetry breaking is not one word and touches on superconductivity there. This paper does not enter that classification. The experiments are not treated in detail—the two experiments of 1961 are cited only, with no discussion of apparatus or error. The value of  $\Phi_0$  is not measured—since 2019,  $h$  and  $e$  are exact, so it is a computed value, and this paper only performs that computation. The other twos are not called over again—Paper 157 has already called over the twos of this series. This paper adds one line and does not redo the classification. The specialness of two dimensions is not conflated with this—the two of Paper 251 is a dimension of space, and the two here is a count. Relation to earlier papers: Paper 157, “A Census of the Twos”, counted across this series the twos that appear—this paper adds one row to that table: the two as a count of carriers. Paper 251 showed that special in two dimensions is not one phenomenon—that two is a dimension and this one is a count, so they are distinct roots. Paper 240 counted “mass” as seven things—the same shape of roll call. Paper 190 measured rare on a logarithmic scale—this paper writes in the digits of exact values. What is added is setting  $h/e$  against  $h/2e$  and obtaining a ratio of exactly 2.0, writing that this two was settled by measurement rather than by theory, writing that it has since moved to the side of definition, and setting  $K_J$ , which carries the two, beside  $R_K$ , which does not, and placing the separator at “a pair or one at a time”.

## 1. Notation and Placement

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**Setting:** the magnetic flux threading a superconducting ring cannot take continuous values. **It takes only integer multiples of a unit, and that unit is the flux quantum  $\Phi_0$ .**

**What is received:** Paper 157 called over the twos appearing across this series. This paper receives that table as a premise—and does not redo the classification.

**Question:** which of the entries in that table does the two in the denominator of  $\Phi_0$  share a root with?

The answer is none of them. It is neither a dimension, nor an exponent, nor a factor—it is how many carriers make one unit of charge.

## 2. The Two Candidates in Numbers

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**Setting:** flux quantisation follows from the condition that the phase return to itself around a loop. **With a carrier of charge  $q$  the unit is  $h/q$ .**

**Check 2.1:** with  $h = 6.62607015 \times 10^{-34}$  J s and  $e = 1.602176634 \times 10^{-19}$  C, both exact in the SI of 2019.

| Carrier                | Charge $q$ | Unit $h/q$                       |
|------------------------|------------|----------------------------------|
| One electron           | $e$        | $4.135667697 \times 10^{-15}$ Wb |
| Two electrons (a pair) | $2e$       | $2.067833848 \times 10^{-15}$ Wb |
| Ratio                  | —          | <b>2.0</b>                       |

**Observation 2.2**

the ratio is exactly 2.0. On the page the two expressions have the same form and differ only in the denominator—and which is right does not come out of the expressions.

**Observation 2.3**

here is the entrance to the point of this paper. The number two was not derived inside the expression; it entered from outside it.

**3. The Core: Measurement Settled It**

**Observation 3.1**

in 1961 two experiments measured the flux quantum independently. Both returned  $h/2e$ —the carrier was not one electron but two making one.

**Check 3.2:** set out what measurement excluded.

| Carrier assumed | Predicted $\Phi_0$               | Against measurement |
|-----------------|----------------------------------|---------------------|
| One electron    | $4.135667697 \times 10^{-15}$ Wb | twice too large     |
| Two electrons   | $2.067833848 \times 10^{-15}$ Wb | it agrees           |
| Three electrons | $1.378555899 \times 10^{-15}$ Wb | 1.5 times too small |

### Observation 3.3

all three candidates come out of the same form of expression. What chose was measurement, not a necessity inside the theory—this two is a number settled by measuring.

### Observation 3.4

the separator—what has to be changed for the two to change. Changing the carrier. Neither  $h$ , nor  $e$ , nor the dimension, nor the phase condition has been moved—what moves is only the count entering the denominator.

### Observation 3.5

the twos called over in Paper 157 lay on the side of dimension, exponent and factor. The two here is a count and is a distinct root from every one of them—one more origin has been found for the same symbol.

## 4. It Has Since Moved to the Side of Definition

Check 4.1: the SI revision of 2019 made  $h$  and  $e$  exact. So  $\Phi_0$  too is an exact value obtained by computation.

| Quantity        | Value                                    | Standing         |
|-----------------|------------------------------------------|------------------|
| $h$             | $6.62607015 \times 10^{-34} \text{ J s}$ | exact (defined)  |
| $e$             | $1.602176634 \times 10^{-19} \text{ C}$  | exact (defined)  |
| $\Phi_0 = h/2e$ | $2.067833848 \times 10^{-15} \text{ Wb}$ | exact (computed) |

### Observation 4.2

the standing of the number two has moved with the times. In 1961 it was something to be settled by measurement, and now it sits on the side of computation from defined constants.

Observation 4.3

a point to state honestly—what became exact are  $\hbar$  and  $e$ , and the two was not defined. The two remains a fact about the physics, and if the pairing broke the denominator would change.

5. Constants That Carry the Two, and One That Does Not

Check 5.1: set out two constants from superconductivity and one from the quantum Hall effect.

| Constant                    | Expression  | Value                            | Carries a two? |
|-----------------------------|-------------|----------------------------------|----------------|
| Josephson constant $K_J$    | $2e/\hbar$  | <b>483597.8484170</b> GHz/V      | yes            |
| Flux quantum $\Phi_0$       | $\hbar/2e$  | $2.067833848 \times 10^{-15}$ Wb | yes            |
| von Klitzing constant $R_K$ | $\hbar/e^2$ | <b>25812.807459</b> $\Omega$     | no             |

Observation 5.2

all are built from the same  $\hbar$  and  $e$ , and yet some carry a two and one does not. Set side by side, what calls the two becomes visible.

Observation 5.3

the separator—what calls the two. Whether a pair is carried or one is counted at a time.  $K_J$  and  $\Phi_0$  are quantities carried by Cooper pairs, so a two stands;  $R_K$  counts the conduction of single electrons, so none does.

Observation 5.4

the  $e^2$  of  $R_K$  is an exponent of two, and not a count of two. Two twos of distinct root stand in the same table—the place where the census of Paper 157 tells.

## 6. Roll Call and Closing

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1. Two candidates(Check 2.1):  $4.135667697 \times 10^{-15}$  and  $2.067833848 \times 10^{-15}$  Wb.
2. The ratio is exactly 2.0(Observation 2.2): the forms are the same.
3. Measurement chose(Observation 3.1): two independent experiments in 1961.
4. Three candidates, one form(Check 3.2): what chose was measurement.
5. The separator is the carrier(Observation 3.4): only the count in the denominator moves.
6. Distinct from Paper 157's twos(Observation 3.5): neither dimension, exponent nor factor.
7. Now an exact value(Check 4.1): because  $h$  and  $e$  are defined.
8. The two was not defined(Observation 4.3): it remains a fact about the physics.
9. It stands in  $K_J$  and not in  $R_K$ (Check 5.1): a pair, or one at a time.
10. Two distinct twos in one table(Observation 5.4): the two in  $e^2$  is an exponent.

Closing: Paper 157 called over the twos appearing across this series. The two standing in the denominator of the flux quantum turned out to be a distinct root from every entry in that table—neither a dimension, nor an exponent, nor a factor, but how many carriers make one unit of charge. The expressions admit  $h/e$  and  $h/2e$  in the same form and do not settle which is true—what settled it was the measurement of 1961. Since 2019,  $h$  and  $e$  being exact,  $\Phi_0 = 2.067833848 \times 10^{-15}$  Wb is exact too, and yet the two itself was not defined—were the pairing to break, the denominator would change. And  $R_K = h/e^2$ , built from the same  $h$  and  $e$ , carries no such two—the two there is an exponent, not a count. One thing separates them—writing down where the two came from. Write it down, and a two that came out of an expression separates from a two that was settled by measuring. Do not write it down, and one reads the two twos in a single table as the same thing.

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