# Quantum step resistance dissipation from electron to electron binding energy in (2DEG) and (1DEG) conduction


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**The Integer Quantum Hall Effect (IQHE) step resistance plateaus, in a two degree (2DEG) electron gas, discovered in 1980[1] and the Fractional Quantum Hall Effect (FQHE) discovered in 1982[2], required low currents, low temperatures and high magnetic fields. In 1988[3,4], it was discovered (even at room temperature and no magnetic field) that quantum step conduction would also occur, with a one degree (1DEG) electron gas in separating point contacts or in necking extrusions. In the intervening years, the open questions were: What is the cause of energy dissipation in the $(h/e^2)$ quantum step resistance plateau values, and why are the quantum resistances insensitive to geometry? The answers have now been found[5], using (a previously unknown) electron to electron binding energy, resistance dissipation energy. The Planck constant (*h*) is derived from the electron binding energy physics, and thus obtains the $(h/e^2)$ von Klitzing constant $R_K = 25812.8074\Omega$ ab initio. The von Klitzing pair and Cooper pair physics occurs only in the *first pair* as they bind onto the electron waveguide EWG channel, making the quantum resistance insensitive to channel length. Only the von Klitzing resistance constant $(R_K = 25812.8074 Ohm)$ is available to make up the quantum step plateaus, thus, the various resistances of the step plateaus are the result of parallel and series combinations of $(R_K)$. These new results also are applicable to the familiar Josephson junction Cooper pair effects.**

The International Council for Science, Committee on Data for Science and Technology (CODATA) accepted von Klitzing resistance standard is $R_K = 25812.807449 Ohm$, or exactly $(h/e^2)$, where (*h*) is the Planck constant and (*e*) is the fundamental charge. The IQHE plateau resistances are relatively insensitive to geometry and are very robust, allowing the related fundamental physical constants to be standardized. Experimentally, the IQHE step resistance plateaus have the values of; $R_H = h/ie^2$ where the coefficient $i$ = 1, 2, 3, 4…. and the FQHE has coefficient values (among others) of $i$ = 2/3, 3/5, 2/5, 1/3,…. (Fig. 1).

Experimentally, the 1DEG quantum wire conduction consists of Cooper pair to Cooper pair double channels giving a two in the numerator and making conductance, $R_C = i(2)\cdot e^2/h$ in reciprocal Ohm, with the coefficient values of, $i$ = 1, 2, 3, 4,…(see Fig. 2). Some quantum wire conditions[6,7], however, can produce an anomalous plateau at $i$ = 0.5. This anomaly is from conduction of a single channel von Klitzing pair formation, $R_K = h/ie^2$, $i$ = 1. The anomaly is labeled a 0.5 plateau, however, when using the reciprocal Ohm units, of Cooper pair conductance $(G_0 = 2e^2/h)$.

Heretofore, theory has not been able to show the exact physical cause for the Planck constant (*h*) in the step resistance $R_K = h/e^2$ persistent value. New avenues, for such a theory development, are described in "The New Quantum Vector Particle Physics"[5] (QVPP). The QVPP[5] presents an electron electromagnetic structure, that derives a (previously unknown) internal electron flux quantum $(\phi_e = \alpha \cdot h/e)$ where $(\alpha)$ is the fine structure constant.

The QVPP[5] also reveals that the strong force is electromagnetic, on account of the superior (near field) magnetic moment forces, between binding particles. The electron has the largest magnetic moment of any sub-atomic particle. These new understandings now show that the electromagnetic strong force can bind electron to electron, as in Eq. (1). A graph of the von Klitzing and Cooper pairing forces are shown in a computer generated graphics in Fig. 3. The Fig. 3 graph uses electron characteristics of charge (*e*) and magnetic moment $(\mu_e)$ to deduce the electron to electron binding energy source, for the quantum step resistance plateaus. In Fig. 3, the von Klitzing electron pair, pole to pole, binding energy release, of $5.9674\cdot10^{-16} J$ occurs at $3.866\cdot10^{-13} m$ pair separation. Also shown in Fig. 3, the Cooper electron pair, dipole to dipole, binding energy release, of $8.4393\cdot10^{-16} J$ occurs at $2.733\cdot10^{-13} m$ separation.

In Fig. 4a, b, c, the possible electron pairings are shown schematically, with the spin axis direction arrows and the magnetic moment North (N) and South (S) poles labeled. In Fig. 4a, the von Klitzing pairing is magnetically forced to be spin polarized, but in Fig. 4b, 4c, the Cooper pairing is magnetically forced to be spin degenerate. The magnetic attracting force varies inversely as the forth power, of the magnetic pole separation distance (*d*) as in $(F_\mu = \mu_0 \cdot \mu_e \cdot \mu_e / \pi \cdot d^4)$. Consequently, in the near field, the magnetic attracting force can greatly exceed the (enormous) repelling electric force, between electrons, because the electric force (only) varies inversely as the square of the separation distance (*d*) as shown in $(F_e = e^2/4\pi \cdot \varepsilon_0 \cdot d^2)$. Where $(\varepsilon_0)$ is

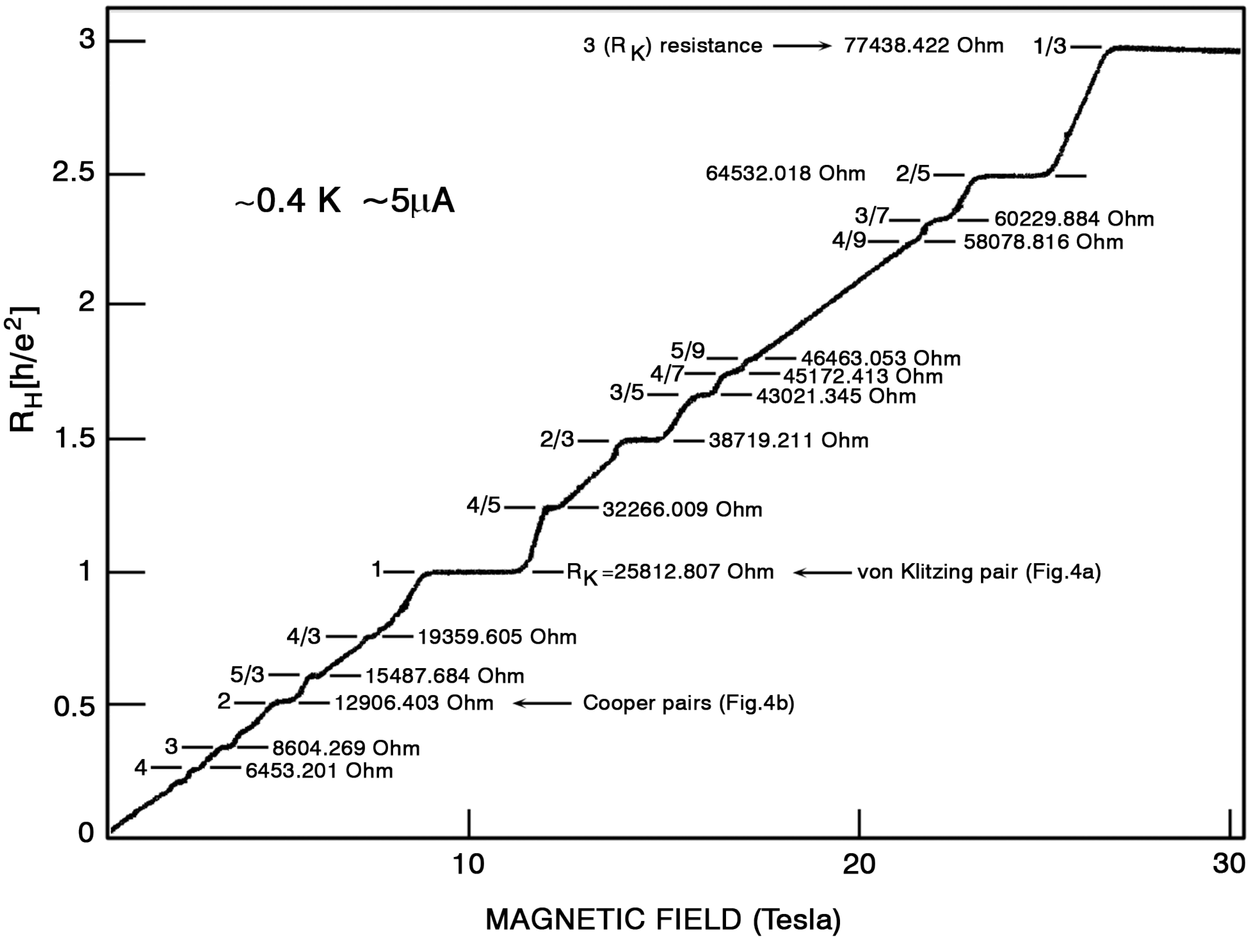


**Figure 1 Typical 2DEG IQHE and FQHE quantum step resistance.** The IQHE and FQHE step resistances are graphed to explain that the resistance can only be series and parallel combinations of the quantum von Klitzing resistance $R_K = 25812.807 Ohm$ . See text and Fig. 4, the Cooper pairs are two von Klitzing resistances in parallel, $i = 1/3$ is three $R_K$ in series, etc. In a 1DEG break junction case, Fig. 2, nature prefers the lower energy state Cooper pairs giving conductance as parallel combinations of the $R_K^{-1}$ .

the permittivity, $(\mu_0)$ the permeability and $(\mu_e)$ is the electron magnetic moment. Thus, the electron binds to the electron, by using the superior magnetic moment attracting force, and in the process creating a mass defect binding energy photon. A photon has, by definition, exactly equal electric E=*V/m* and magnetic H=*A/m* field strengths, where (*V*) is Volt, (*A*) is Ampere and (*m*) is meter. When the electric and magnetic (EM) energy forces $(F_e, F_\mu)$ suddenly become exactly equal, as pairing electrons approach each other at (d), the EM equality condition creates the photon that *quantifies* the binding energy mass defect.

The room temperature (typical) quantum step conductance is demonstrated (Fig. 2), in a mechanically controlled break junction (MCB)[8,9] or in break point junctions using a Scanning Tunneling Microscope (STM)[8]. The MCB and STM demonstrate the step conduction, at room temperature and zero magnetic fields, requires no outside forces, other than the applied line current and the apparatus voltage used to expand the piezoelectric actuator, for the micro reduction of the point contact area[8,9]. The electric field strength in a small conduction area or near a sharp point will be amplified, by well known physics. This electron funneling effect produces the required high electric fields, for forcing electron to electron binding, from the bulk terminal narrowing into the small cross-section 1DEG quantum wire. The binding energy, for the single von Klitzing pair of electrons (Fig. 4a), will now be calculated, from the electron electric and magnetic forces. The charges and magnetic moments, of two electrons interacting, will result in a binding energy mass defect, by creation of a photon, at the instant electron to electron electric forces $(F_e = e^2/4\pi \cdot \varepsilon_0 \cdot d^2)$ equal the electron to electron magnetic forces $(F_\mu = \mu_0 \cdot \mu_e \cdot \mu_e / \pi \cdot d^4)$. The resulting von Klitzing electron to electron, pole to pole binding energy $(B_e)$ photon is suddenly produced, the instant the attracting magnetic moments $(\mu_e, \mu_e)$ have become equal to the electric $(-e, -e)$ charge repulsion, in the near field, at $3.866 \cdot 10^{-13} m$ separation, Fig. 3. The calculations start by converting Newton forces to Joule by $(F_e \times d,\ F_\mu \times d)$ and combining the resulting energy equations, at a common separation (*d*). The binding energy $(B_e)$ in Joule is then calculated by the resulting:

$$B_e = \sqrt{\frac{e^6}{64 \cdot \pi^2 \cdot \varepsilon_0{}^3 \cdot \mu_0 \cdot (\mu_e \cdot \mu_e)}}$$
$$= 5.9674987246 \cdot 10^{-16} \cdot kg \cdot m^2 \cdot s^{-2}, \quad (1)$$

where $(\mu_e = -928.476412 \cdot 10^{-26} A \cdot m^2)$ is the standard CODATA electron anomalous magnetic moment. The von Klitzing pole to

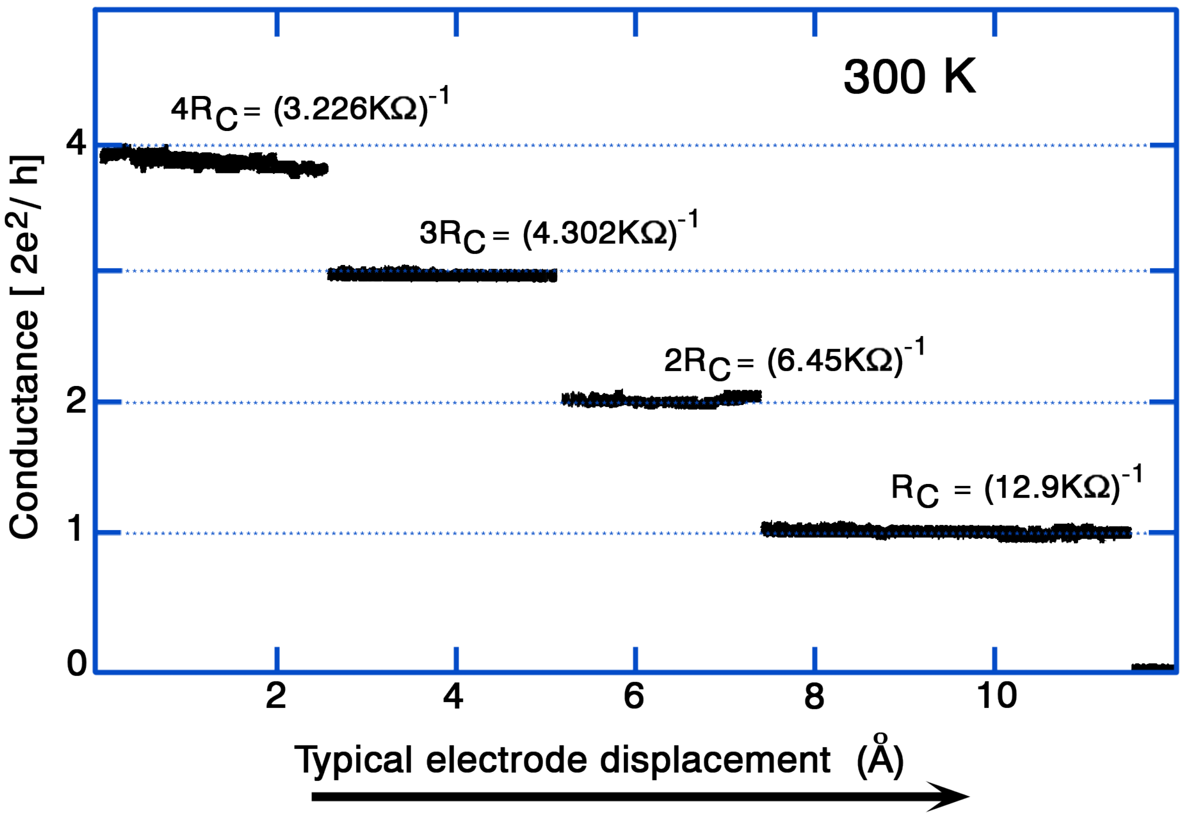


**Figure 2 Typical 1DEG break junction step conductance.** Step conductances in separating break junctions are Cooper pair reciprocal resistance, see Fig.4 (b). The conductance of 1 in those units gives a value of $R_C = (12.9K\Omega)^{-1}$ as $(R_K/2)^{-1}$ or two parallel $(25.8K\Omega)^{-1}$. Note this is the least number of electrons as the break junction separates at about 8 Angstroms, typically. The conductance of (2) consists of two $R_C$ in parallel. The conductance at (3) consists of three $R_C$ in parallel. The conductance at (4) consists of four $R_C$ in parallel. The Cooper pairing resistance is produced as each Cooper pair bind to the channel. The bound Cooper pairs are robust lowest energy states until their mass defects can be replaced.

pole bond length at binding, between electrons, is the null distance ($d$) obtained by combining $(F_e, F_\mu)$ resulting in:

$$d = \sqrt{\frac{4 \cdot \varepsilon_0 \cdot \mu_0 \cdot \mu_e \cdot \mu_e}{e^2}} = 3.8660707914721 \cdot 10^{-13} \cdot m. \quad (2)$$

It is noted, from use of the anomalous magnetic moments $(\mu_e, \mu_e)$ that Eq. (2) $3.8660707914 \cdot 10^{-13} m$ is equal to $[d = (\lambda_e / 2\pi) \cdot (1 + \alpha_e)]$ where $(\lambda_e / 2\pi = 3.861592678 \cdot 10^{-13} m)$ is the electron rationalized Compton wavelength, and $(1 + \alpha_e) = 1.00115965218$ is the well known electron g/2 factor. The photon will have an energy, from the von Klitzing pole to pole pair formation, of $5.96749872 \cdot 10^{-13}$ *Joule* mass defect, Fig. 3. The electron to electron binding energy, embodied in the newly created photon, releases the pair mass defect (energy), thus binding the pair of electrons, at the (d) separation, until the missing (mass) energy can be replaced, much the same as nucleon to nucleon atomic binding energy processes[5]. The frequency, $(N = A/e)$ of the new pair formation, equals the number of conduction electrons per second, from the low density electron conduction current ($A$) Ampere. After the active pair binding energy (photon) is released, the ground state bound pair then is visualized as joined, at the electron conduction current frequency ($N$), by another pair forming onto the bound EWG channel, of superconducting electrons, as in Fig. 4a. The quantum conduction resistance, as a result of the binding energy $(B_e)$ photon and bond length ($d$), as each new electron pair joins the ground state electron bound channel, can now be calculated.

Basically, a resistance ($R$) is characterized by a voltage drop ($V$) proportional to current flow ($A$) Ampere. For a constant ($R$) the ratio of ($V/A$) must remain constant. These are the necessary elementary conditions for obtaining the quantum step resistances. The CODATA characteristics, for the electron, are known to within a few parts per billion uncertainty. The calculated electron to electron binding energy $(B_e)$, Eq. (1) and separation ($d$), Eq. (2), at binding, have now been obtained by the QVPP[5] derived equations. What must now be done, analytically, is to determine the physics producing the Planck constant ($h$), from the deduced band gap energy. The band gap energy is known to be $[Eg = (h \cdot F_V)/d]$, where ($d$) is the band gap length, Eq. (2) and $(F_v)$ is the Fermi velocity. The Fermi velocity $(F_v)$ is found to be quantized at $(F_V = c \cdot \alpha / 2 \cdot \pi)$ where ($c$) is the velocity of light, $(\alpha)$ is the fine structure constant. The fine structure $(\alpha)$ is, by definition, the dimensionless ratio between the electron electrical (or magnetic) potential energy, and the electron rest mass energy. The fine structure $(\alpha)$ sets the scale, and the rationalized velocity of light $(c/2\pi)$ gives the effective electron velocity at binding. Knowing the Fermi velocity, $(F_v)$ in the band gap energy equation $[Eg = (h \cdot F_V)/d]$, now allows deducing the Planck constant ($h$) from the binding energy physics. The Planck constant has the dimensions of Joule seconds, representing a fixed quantity of the electron binding energy. We use the calculated electron binding energy $(B_e)$ and the deduced separation ($d$) band gap length, as determined earlier by Eq. (1) and Eq. (2). By setting ($Eg$) equal to $(B_e)$ algebra obtains $(h = (2 \cdot \pi \cdot B_e \cdot d)/\alpha \cdot c)$ giving the published Planck constant value as the expected CODATA $[h = 6.6260693 \cdot 10^{-34} \cdot kg \cdot m^2 \cdot s^{-1} (J \cdot s)]$ from $(B_e \cdot d)$. This derivation, of the Planck constant ($h$), from the pair binding energy $(B_e)$ and bond length ($d$) and Fermi velocity $(F_v)$ rather than simply inserting the ($h$) published Planck value, immediately obtains the von Klitzing and Josephson constants ab initio. The ($h$) derivation, from the binding energy physics, serves to give the quantum step resistance mathematics a logical basis.

The standard Josephson constant $R_J = (2e/h)$ has the dimensions of Hertz per Volt. The inverse of $(R_J)$ is the standard flux constant $(\Phi_0 = h/2e)$ =Weber, Volt per Hertz, or Volt seconds. The Volt seconds, across the Cooper pair to Cooper pair binding, to the electron waveguide (EWG) junction (Fig. 4b) is then for two channels, which divides the line current and effectively gives the standard Weber $(\Phi_0 = h/2e)$ flux quantum. The Volt second $(V \cdot s)$ with the full line current, of a single von Klitzing electron junction Fig. 4a is, however, effectively twice the standard Josephson junction $\Phi_0$ fluxon, giving simply ($h/e$):

$$V \cdot s = \frac{(2 \cdot \pi \cdot Be \cdot d)}{(e) \cdot \alpha \cdot c} \qquad (3)$$

$$= 4.13566742 \cdot 10^{-15} \cdot kg \cdot m^2 \cdot s^{-2} \cdot A^{-1}\, Weber.$$

The voltage drop $(V_K)$, as the von Kiltzing electron to electron binding junction forms, depends on the current ($A$) forming the junction quantum step resistance. The current can be selected *arbitrarily*, since resistance only depends on a constant ratio $(V_K / A)$. For demonstration, a current of 5 micro-ampere $(5 \cdot 10^{-6}\, Ampere)$ is chosen. The frequency, in Hertz, or reciprocal seconds $(s^{-1})$ is then taken as equal to the number of electrons ($N$) per second:

$$N = [(5 \cdot 10^{-6} A)/(e)] = 3.12075473 \cdot 10^{13} \cdot s^{-1}. \qquad (4)$$

The voltage drop $(V_K)$, across a single electron (von Klitzing) pole to pole binding junction is then:

$$V_K = V \cdot s \cdot N = 0.129064037 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}\ Volt. \qquad (5)$$

Then, finally, at the current chosen, and voltage drop $(V_K)$, from the *Volt seconds* $(V \cdot s)$ and frequency of pair formation (N) Eq. (4), gives the fundamental von Klitzing quantum step resistance $(R_K)$ constant:

$$R_K = \frac{V_K}{(5 \cdot 10^{-6} A)} = 25812.8074 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}\ Ohm\ \Omega. \qquad (6)$$

We see that this (arbitrarily chosen) current of 5 micro-Ampere, derives the von Klitzing fundamental resistance constant, from the voltage drop $(V_K)$, Eq. (5). Equivalently, from QVPP[5] fundamentals:

$$R_K = \frac{2 \cdot \pi \cdot Be \cdot d}{e^2 \cdot \alpha \cdot c} = 25812.8074 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}\ Ohm\ \Omega, \qquad (7)$$

and, equivalently, from dimensional analysis,

$$R_K = \frac{h}{e^2} = 25812.8074 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}\ Ohm\ \Omega. \qquad (8)$$

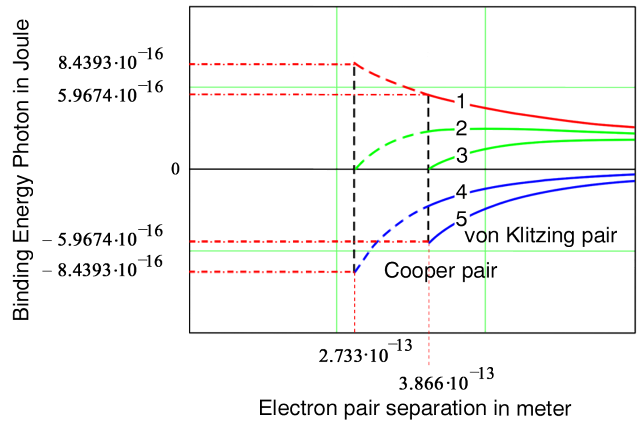


**Figure 3 Quantum electron pair binding.** Trace (1) is the binding electrons $(e-, e-)$ electrical potential energy common to both von Klitzing and Cooper pairs. Trace (4) is the magnetic potential energy between Cooper pair electron magnetic moments. Trace (2) is the energy difference between Trace (1 and 4). Trace (5) is the magnetic potential energy between electrons of the von Klitzing pair. Trace (3) is the energy difference between Trace (1 and 5). As Trace (2) and (3) become zero, the equal electric and magnetic force conditions create a photon. The photon then releases the mass energy defect which binds the electrons until the missing mass energy can be replaced.

We have now shown, from first principles, that the QVPP[5] von Kiltzing electron binding energy $(B_e)$ mass defect and electron to electron band gap length ($d$) for the electron to electron binding, gives the true mechanism for creating the measured quantum step resistance, of $(R_K)$.

The Fig. 4c Cooper pair binding can now be calculated in a similar fashion to the von Klitzing pair, Fig. 4a, except that the dipole to dipole magnetic moment forces (dotted lines in Fig. 4) are exactly one half of the pole to pole magnetic moment forces. Because the strong force is the conjunction, of both electric and magnetic forces, the Cooper pair electrons must move closer and this results in a (counter intuitive) increase in binding energy, from the half magnetic force. See the Fig. 3 graph of forces showing the Cooper pair greater binding energy, from the Cooper pair dipole to dipole configuration. The Cooper pair binding energy is calculated:

$$CB_e = \sqrt{\frac{e^6}{32 \cdot \pi^2 \cdot \varepsilon_0^3 \cdot \mu_0 \cdot (\mu_e \cdot \mu_e)}} \qquad (9)$$

$$= 8.4393176297 \cdot 10^{-16} \cdot kg \cdot m^2 \cdot s^{-2}.$$

In the Fig. 3 graph, the Cooper pair clearly shows the effect of the dipole to dipole magnetic moment half force. Notice that the electrons, in the dipole to dipole Cooper pair, have moved closer, to $2.733 \cdot 10^{-13} m$ separation, so that the more rapidly growing (but initially weaker) dipole to dipole magnetic force, trace(4) then becomes equal to the increased electric force, trace(1), at the $2.733 \cdot 10^{-13}$ *meter* separation. It is apparent in Fig. 3 that the dipole to dipole Cooper pair $(CB_e)$ $8.4393 \cdot 10^{-16} J$ is larger than von Klitzing pole to pole pair $(B_e)$ $5.9674 \cdot 10^{-16} J$. The Cooper pair is thus the lowest energy state (greater mass defect) because the photon releases the greater $8.4393176297 \cdot 10^{-16} J$ mass

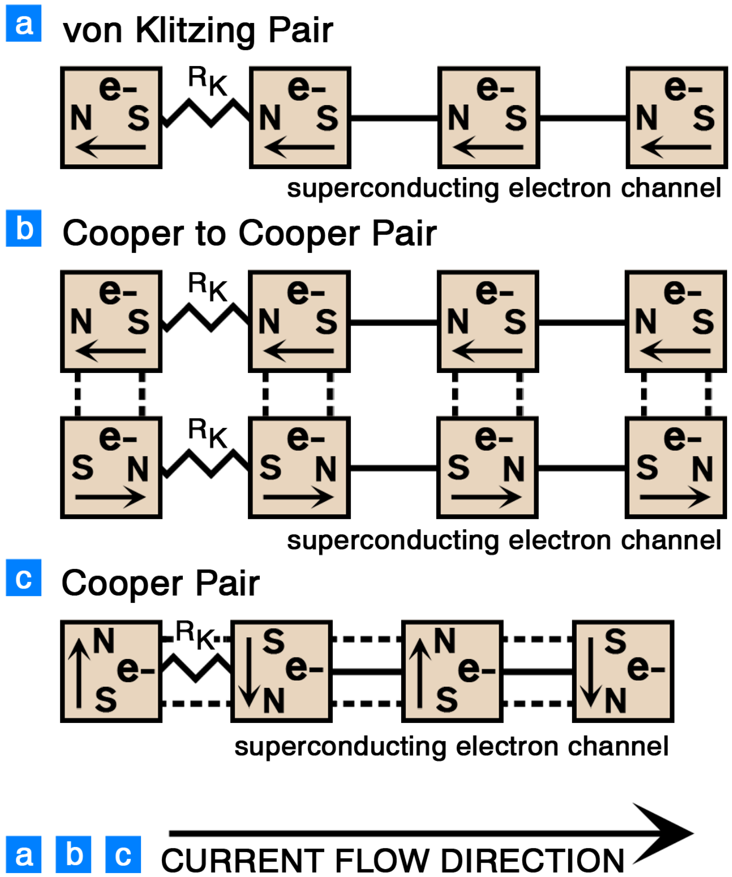


**Figure 4 All possible electron pairing.** a. As each von Klitzing pair form, they produce the $R_K = 25812.807 Ohms$ and join the superconducting channel. The von Klitzing pair are magnetically forced to be spin polarized. b. Cooper pair binding to Cooper pair is two von Klitzing channels joined by the dipole to dipole magnetic attraction (shown as dotted lines). The spins are magnetically forced to be degenerate. c. Here is a possible dipole to dipole joining of Cooper pairs with anti-parallel (degenerate) spins, electron to electron. The Cooper pairing also produces $R_K = 25812.807 Ohms$ because the product of binding energy and binding separation is the same as the von Klitzing pairing. (See text.)

energy. The lower mass defect energy state, of the Cooper pair configuration, will be preferred by nature, especially in the (room temperature) break junction, or even in the low temperature quantum wire environment, thus giving the experimentally obtained step conductance reciprocal Ohm plateaus from $R_C = (i)2e^2/h$ with coefficients ($i$) = 1, 2, 3, 4,….(Fig.2). It should be noted, however, in atomic nuclei nature seems to prefer that nucleons share the same spin axis, at least initially, even though the anti-parallel spins binding are the lower mass energy state. For example, in an isolated deuterium nucleus, the deuteron proton and neutron always share the same spin axis, for a total spin of one[5]. But, the Cooper pairs do not exist alone, like the deuterons can, but rather are joined to other Cooper pairs (see Fig. 4b, c) and this binding stabilizes the Cooper pair, by being attached to a channel of Cooper pairs. If a free Cooper pair initially forms with a common spin axis, so magnetic moments first add, one electron will quickly be forced to spin flip, into the lower energy state, thus joining other bound Cooper pairs in the channel. The Cooper pair separation distance ($dd$) at binding, calculates:

$$dd = \sqrt{\frac{2 \cdot \varepsilon_0 \cdot \mu_0 \cdot \mu_e \cdot \mu_e}{e^2}} = 2.73372487319 \cdot 10^{-13} \cdot m. \qquad (10)$$

Interestingly, the quantum resistance depends on the product of $(B_e \cdot d)$ to derive the Planck constant ($h$). We find $(CB_e \cdot dd) = (B_e \cdot d) = (2.30707725173475 \cdot 10^{-28} J \cdot m)$, as a new fundamental constant, one that consistently obtains the Planck constant ($h$) directly from the electron binding energy band gap physics, thus assuring that the quantum step resistances are all based on $(R_K)$. The Cooper pair to Cooper pair binding is equivalent to two von Klitzing pair bound together in parallel (see Fig. 4a, b). The conclusion is that step plateau resistances, at any value, other than $(R_K)$, are made up of parallel and/or series combinations of the von Klitzing resistance constant $(R_K = 25812.8074\Omega)$ (Fig. 1, 2). Figure 4c shows that the anti-parallel spin electron Cooper pair coupling, to a quantum wire, is also possible. Again, in Fig.4c, the single Cooper pair quantum resistance is (also) the von Klitzing resistance $(R_K)$ as a consequence of the constant product of binding energy times the band gap length. $(2.30707725173475 \cdot 10^{-28} J \cdot m)$.

We can now proceed to calculate, the Fig. 4b Cooper pair to Cooper pair resistance value, in a fashion similar to Eq. (3-8). The dipole to dipole flux $(V \cdot s)$, of the Cooper pair to Cooper pair binding, Fig. 4b, is the well known flux quantum $(\Phi_0 = h/2e)$ from the QVPP[5] previously derived Planck constant, and resulting as follows:

$$V \cdot s = \frac{(2 \cdot \pi \cdot CBe \cdot dd)}{2 \cdot (e) \cdot \alpha \cdot c}$$
$$= 2.06783372 \cdot 10^{-15} \cdot kg \cdot m^2 \cdot s^{-2} \cdot A^{-1} Weber. \qquad (11)$$

Using $N$ from Eq. 4, we get a Josephson voltage $(V_J)$ across the Cooper pair to Cooper pair:

$$V_J = V \cdot s \cdot N = 0.0645320186 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}\ Volt. \qquad (12)$$

At this voltage $(V_J)$ from the applied but arbitrary 5 micro-Ampere current chosen, the Cooper pair to Cooper pair quantum resistance $(R_C)$ is calculated:

$$R_C = \frac{V_J}{(5 \cdot 10^{-6} A)} = 12906.403 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-2}\ Ohm\ \Omega. \qquad (13)$$

Or, equivalently, from QVPP[5] fundamentals:

$$R_C = \frac{2 \cdot \pi \cdot Be \cdot d}{2 \cdot e^2 \cdot \alpha \cdot c} = 12906.403 \cdot kg \cdot m^2 \cdot s^{-3} \cdot A^{-2} \; Ohm \; \Omega. \qquad (14)$$

As was shown, in Fig. 4b, the Cooper pair to Cooper pair resistance value, Eq. (14), is just a paralleling of two $(R_K)$ von Klitzing pair resistances, giving $R_c = (R_K / 2)$ or (12906.403Ω). The standard flux quantum $(\Phi_0 = h/2e)$ results from a division of line current, in the Cooper pair to Cooper pair two current branches, producing a voltage drop of $(V_J)$= half of the von Klitzing $(V_K)$ voltage, across the pair. The derivation of (*h*) from the binding energy and bond length show nature has only one possible quantum resistance of $(R_K = 25812.8074\Omega)$, from either a pole to pole or a dipole to dipole, electron to electron binding. This seminal fact leads to the conclusion that the quantum step resistances can only be made up of series and/or parallel combinations of $(R_K)$ resistances (Fig. 1, 2). The MCB and STM experimental 1DEG, in the Cooper pair to Cooper pair, produces parallel combinations of the quantum conductance or $R_C = (R_K / 2)^{-1}$ for the step plateaus shown in Fig. 2. Since $(R_K)$ is the only resistance possible, from electron to electron pair binding, the 2DEG (IQHE) quantum resistance steps, can only be $R_K / 2, R_K / 3, R_K / 4$, etc., as a result of parallel $(R_K)$, Fig. 1. The 2DEG (FQHE) (i=2/3, 3/5, 2/5, 1/3…..) then result from electron channels adding in series and/or parallel, for example, (i = 2/3) resistance plateau is $(R_K + R_K / 2)$ the (i =2/5) resistance plateau is $(2R_K + R_K / 2)$ and the resistance plateau (*i* = 1/3) is $(3R_K)$, etc., (Fig. 1).

Further, as a result of these studies, it is concluded that the Josephson junction is not formed by some glamorous tunneling process. It appears the Cooper pair each bind in turn to a Cooper pair, forming a bridging 1DEG channel extension, of bound superconducting electrons (Fig. 4b). The superconducting electron channel is visualized as extending and bridging (not tunneling) across the Josephson junction. The bridged Josephson junction gap then develops a direct current voltage drop, from the repeated first pair as it forms. The familiar Josephson voltage drop $V_J = [(h\,A)/2e^2]$ is set by the current (*A*) used, producing a frequency of $N = A/e$. The Josephson junction negative resistance slope, at bridging, is equivalent to the familiar spark gap breakdown. Arcing across a spark gap results in a negative resistance slope characteristic, by going from high voltage, low current (open circuit) to low voltage, high current (short circuit). The negative impedance slope is able to create a resonance condition, in conjunction with selected circuit inductance and capacitance. It is concluded that a new Cooper pair continually joins the parallel EWG channel, at a frequency of $(N = A/e)$, thus producing the Josephson constant $R_J = (2e/h)$ Hertz per Volt, from the two von Kilitzing pair voltages in parallel.

High transition temperature $T_c$ superconductivity in copper oxides has had no complete theory in the last twenty years.[10,11] Regardless of the superconductor material type, in the final analysis, it must be the electron to electron robust binding that makes up the physics of superconducting currents. The transition to superconduction happens dramatically, when the electron to electron binding suddenly occurs, at the material transition temperature. The temperature transition, in the superconductor material creates a phase change, from free electrons to electrons bound to electrons. The bound electrons form a daisy chain channel, as in Fig. 4. The released binding energy photon carries away mass energy and robustly binds electrons to electrons, with a mass defect. The superconducting current is then the result of a loss-less resonance, in the electron pair bonds. This resonance theory seems logical, since a resonance is the *only* known *loss-less mechanism* in nature's toolbox.

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