Is Physics Ready For Strange Metals?

Translation: I'm ready for strange metals. Are you?

IMPERCEPTIBLE RELICS
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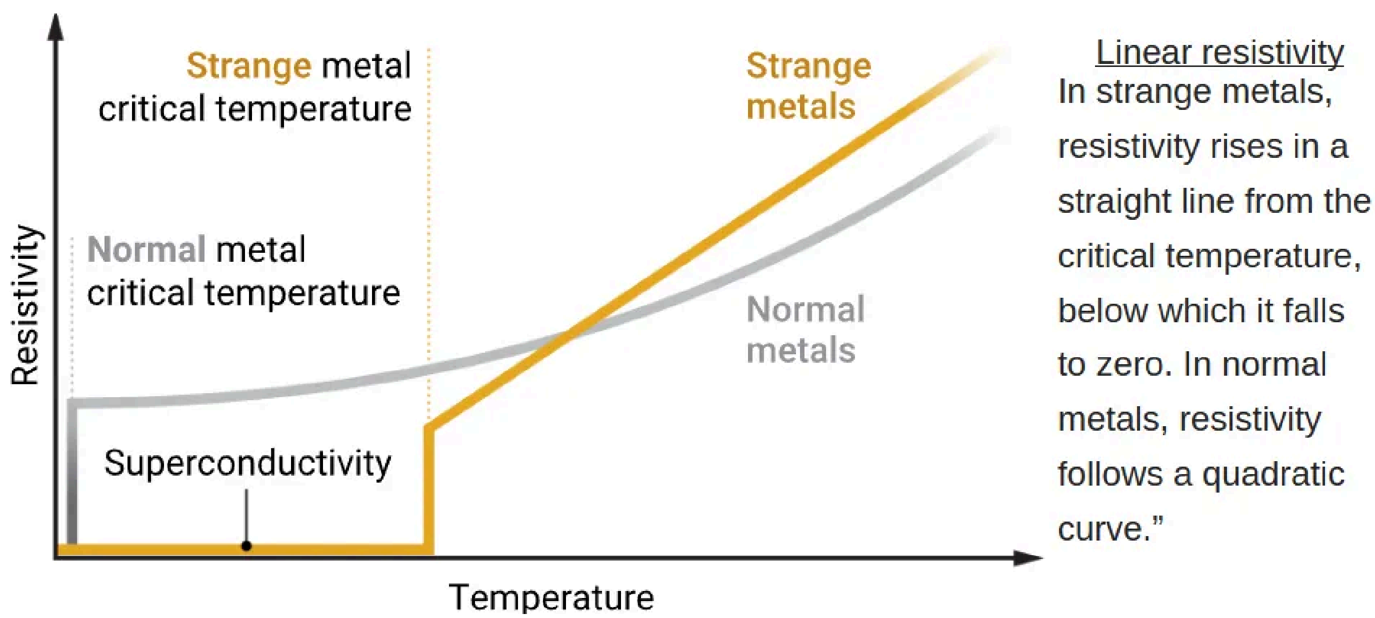
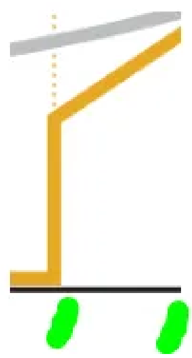
In my never ending quest for knowledge, I occasionally stumble upon new topics that I have not read much about. I have heard of superconductors and various types of particles – Higgs bosons, quasi particles, etcetera, but I haven't noticed much about this unique phase, which apparently is unlike a Fermi liquid. After reading a few articles, what causes me to "notice" an interesting new field isn't so much its trending aspect, but a particular linear graph from a chart that measures resistivity in a metal. From this [*Science*]() article last week:



In strange metals, resistivity rises in a straight line from the critical temperature, below which it falls to zero. In normal metals, resistivity follows a quadratic curve."

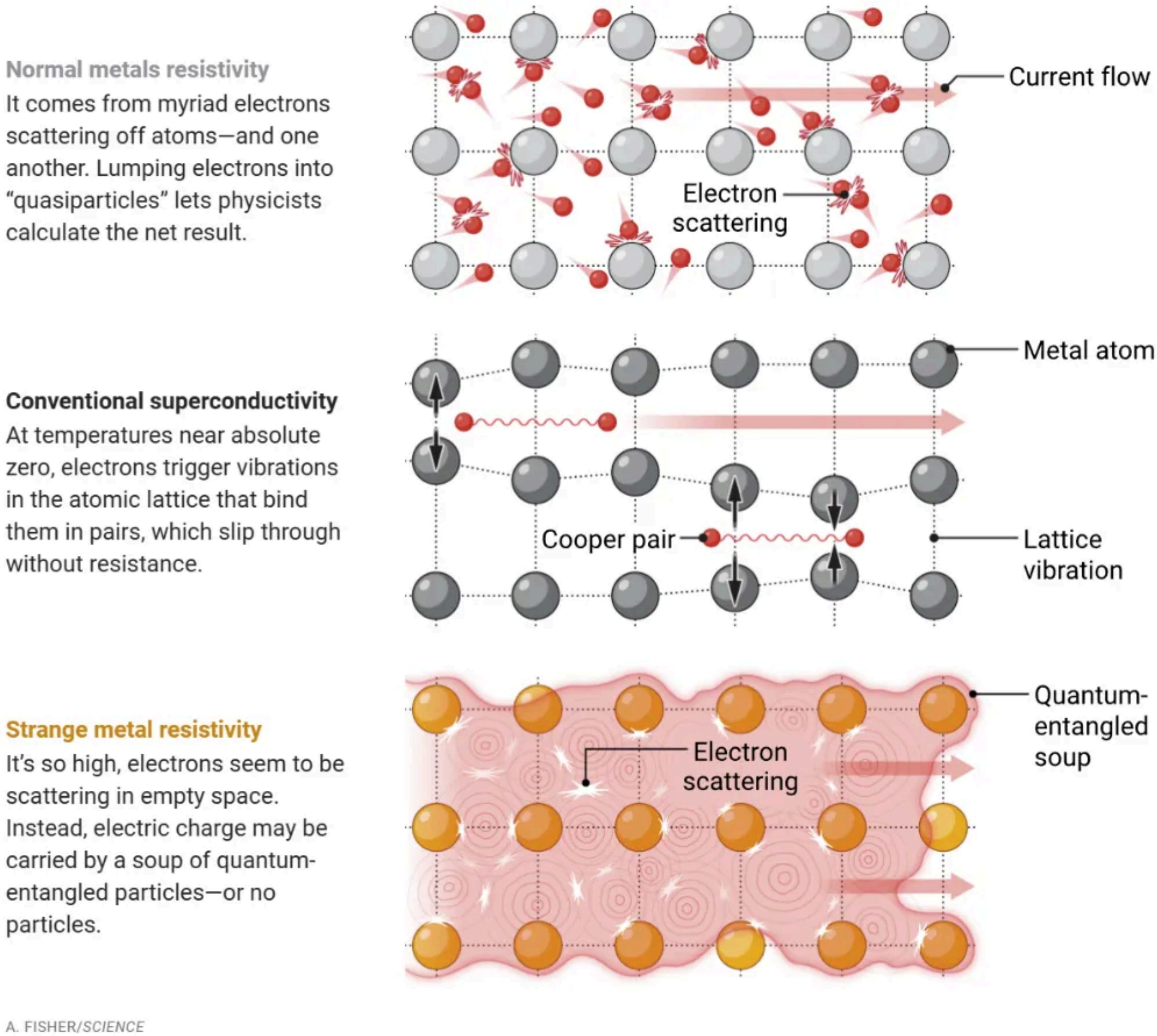
At first glance, it seems *so plausible*. What is being measured suggests it is at the border between a new state of metals that hasn't been delineated before. And it could very well be so. But my underutilized skepticism meter has been yearning for some exercise. What if, the instrument measuring the resistivity isn't keeping up with the actual rise in resistivity after it crosses the normal metal rate, or is reporting a "faster than usual" rise in resistivity before it crosses the normal metal rate?

In the above graph, the normal metals show a quadratic increase in resistivity. That means its resistivity increases faster above a high temperature threshold (the right green mark highlighted below), but crucially, not a lower temperature:



This segment of the graph is where high temperature, "strange metal" superconductors (ones that can be cooled by liquid nitrogen instead of the more expensive liquid helium) can still operate with lower resistance than normal metals (presumably this graph refers to cuprates (synthetic metal) and other metals used for superconductor experiments.

A standard metal operates in a "wave model," where neatly ordered atoms transfer electrons along a Cooper Pair lane when cooled to near zero temperatures.



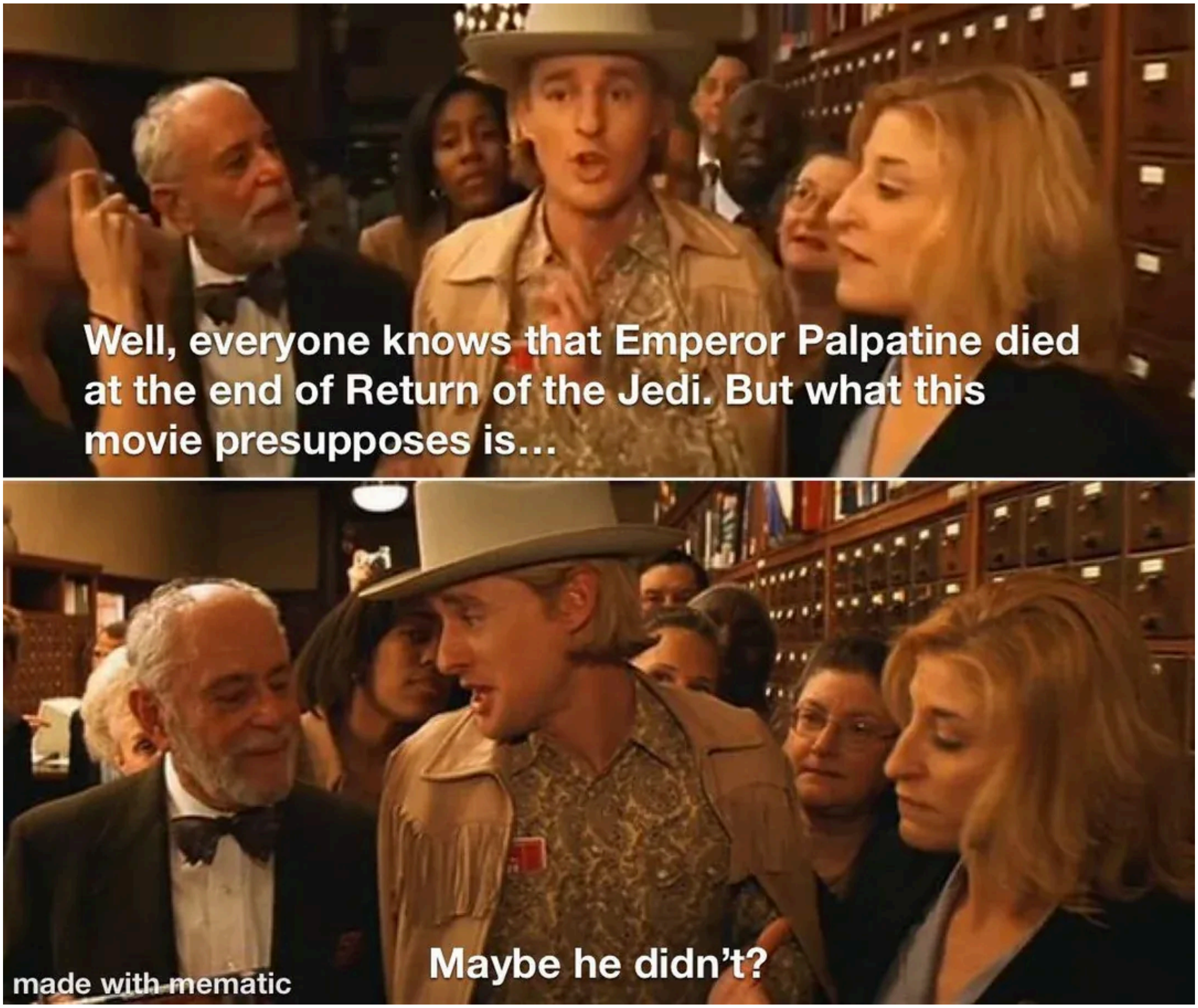
This 2024 Scientific American article addresses the oversimplified model of the electric field, even calling it a "toy model" because of the unaccounted for atoms that form a lattice in crystalline solid (which is a precondition for optimum conductivity for solid metals below a certain temperature). They describe how electrons' kinetic energy collectively forms a high energy state because their electron-electron repulsion is weaker than their tendency to search for lane changes, as in a semi-conductor, or a Fermi liquid:

each other. The Pauli principle is key to why we can get away with this. In atoms, as this law forces additional electrons to go into increasingly high-energy states (also called orbitals), the kinetic energy often ends up being more important than the electron-electron repulsion.

The model, proposed by Lev Landau in 1956, suggests that electrons form a quasiparticle which exists only in a "larger, many-body system."

The article goes on to describe how strange metals appear to defy the quasiparticle model, because while they exhibit decreasing resistance with decreasing temperatures, they are not Fermi liquids, and display a linear proportional increase in resistivity with increasing temperature. The article reminded me of a 2019 Electronic Design article about Bob Pease in 1999 and misconceptions circuit designers had of CMOS transistors, emphasizing the importance of a square-laws effects on subthreshold voltage:

"*Everybody knows that FETs have a square-law characteristic. As the current gets smaller and smaller, the gm [transconductance] per microampere keeps rising to very high levels. Wrong again. The gm per milliampere rises, but tapers up to levels such as 90 or 120 mV per decade. These transistors behave exponentially at low levels, just like bipolars.*"



(Adapted from *The Royal Tenenbaums,* by Wes Anderson, 2001)

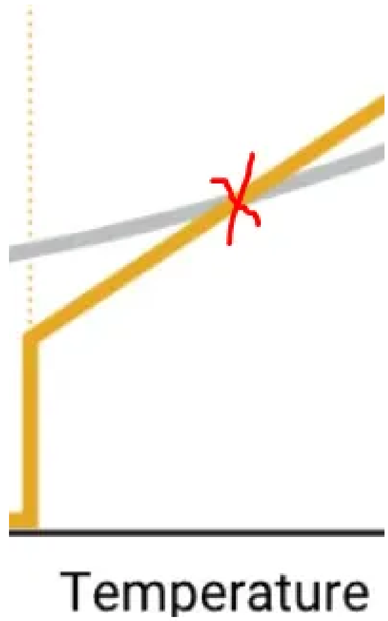
"*Whether the resistivity depends on T or T2 at low temperatures may sound like an innocuous difference, but it's not. This change implies the failure of Fermi liquid theory and, some scientists think, the breakdown of the quasiparticle picture of excited electrons." (SA, 2024)*

It is tempting to want to dump the quasiparticle model, when there is an observed exception to the "rule," because the linear resistivity suggests that the electrons form an entangled "soup" with quantum implications that have not been characterized before. Furthermore, it makes a clear case for having observed the Planckian constant in proportion to the temperature applied:

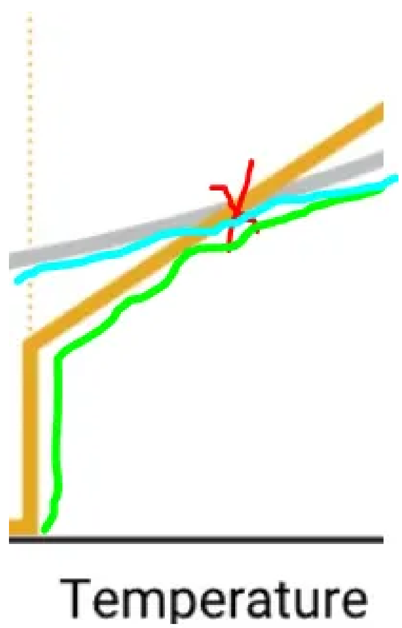
“One fascinating outcome is that the timescale on which the electrons distribute momentum among themselves in many (but not all) strange metals is “Planckian,” meaning it is essentially governed only by quantum mechanics (through what’s called Planck’s constant) and temperature, independently of any details of the materials. This kind of universality among all strange metals, and the fact that strange metallicity appears in many different materials, suggests there is some deeper organizing principle at work.” -*SA, 2024*

As much as I am open to adopting and embracing this universal property of strange metal, since they all defy the Fermi liquid quasiparticle formation, I am cautious to jump the boat yet (the Chinese proverb, “one foot in each boat” comes to mind). Since the cuprate metals are synthetic, I have wondered of the possibility that a unique arrangement of metals not ordinarily found in nature, with no regard to levels of order (e.g. naturally occurring diamonds with a neat lattice) creates some yet unobserved, but higher propensity for LENR within a Bernoulli-like principle and medium. That is, superconductors form Cooper pairs for the electrons in open lanes, but like a *Frogger* arcade game, not all of them are able to cross the street and get run over by quasiparticles, atoms, and other burgeoning orbitals.

But, the electrons are not able to escape the non-porous metal like a pinhole leak in a pipe, and are more attracted to this purported “soup”. They do not form Cooper pairs, and are not measured as “current” per se according to the amp meter or voltometer. Rather, they form Van der Waal-like bonds (which are for atoms, not electrons) in temporary “pockets” of attraction due to the pressure of “scattering” within the Bernoulli-like conductor “pipe”, affecting a small, but sizeable minority of electrons in proportion to the current that is not measured under before it crosses the quadratic line of conventional resistivity.



The strange metal crosses the line when it starts to behave like a conventional metal



In actuality, strange metals may have an alternate conductance (blue) that mimics conventional superconductors, or does so after reaching the same resistance (green)

Where are they going? What if they are forming an “anti BCS Cooper pair,” with no measurable current, but are being encoded in this pipeline, like a pneumatic tube? Or it resembles a superfluid? If it were a non-measurable current, it could be like an out-of-phase 120V wire in a 240V triple phase circuit. The current might not see it as a live line, because it is encoded in a dark matter of electron pairs. Alternatively, it can form a non polar electron scaffold, a neutralized microtubule of electrons propelled by the signal velocity of adjacent lanes, similar to a Maglev train of an electric field, but not able to porously traverse each lane which requires a minimum energy to cross.

According to these sources, the signal velocity in a conventional metal is near 0.6 c, whereas in a superconductor, it is near the speed of light:

https://www.wtamu.edu/~cbaird/sq/2014/02/19/what-is-the-speed-of-electricity/

https://electronics.stackexchange.com/questions/464689/what-is-the-speed-of-electricity

https://physics.stackexchange.com/questions/429381/what-is-the-drift-velocity-of-an-electron-in-a-superconductor

A fiber optic cable is an energy efficient transmission of information. Google Datacenters say so:

"Google, with their Apollo project, has developed a non-blocking 136x136 optical circuit switch that is both forward and backward-compatible with any bandwidth or wavelength Google uses or will use in its data centers. This switch, according to Google, only uses 108 watts of power consumption. Compared to a standard 136 port EPS switch, which would be in the 3,000 watts range."

Even in an ordinary coaxial cable still used by ISPs such as Comcast or Spectrum, quite a bit of data can be transmitted over DOCSIS 3.1 copper (1-2Gbps). While some these strange metal experiments measure the detection (or absence) of quasiparticles, using far infrared light, or, measuring the resistance, they may be indirect and insufficient in measuring the total throughput of all electrons. I'm not saying the meter is broken. I think they actually seem to be on to something, but it doesn't rule out other compensating or emerging phenomena for what initially appears to be a linear measurement. That is, in other words, the resistance may follow a quadratic curve if some of the conductance is being encoded in a different electrical state until it reaches parity with the temperature threshold of conventional metals and exhibits the same or indistinguishable characteristics at higher (and room) temperatures.

Say, for instance, a new experiment were devised where someone wanted to encode a high resolution 200 megapixel image in a superconductor internet cable. It might only require a fraction of the total electrons to transmit along a Cooper pair, and might only take a fraction of a second to transfer the gigabyte .Tiff file uncompressed. But what if there was a way to "tag," perhaps not radioactively, a number of electrons in this image before it passes through a supercooled and superconducting segment of a strange metal? Would all of the "proper" electrons pass only through the Cooper pairs, or would they get stuck in the soup? And, could there be a third path- an alternate dimension, a teleporting pneumatic tube-like lane, which doesn't get measured by the resistivity, but still shows up later along the wire like an encrypted bundle of packets?

Western Union Man, 1955 delivering mail from 1885 *(Back to the Future II, 1989)*

"To explain such high resistance in Landau's framework would require electron quasiparticles to be scattering at distances shorter than there are things to scatter off, in the empty spaces of the atomic lattice."

"In 2004, Dutch physicist Jan Zaanen noted something else about resistivity in strange metals. The slope of a material's resistivity is a measure of how fast it dissipates an electrical current as heat. In normal metals, the electron scattering rates depend on microscopic details of the material. But in strange metals the dissipation—hence the resistivity—always seems to rise at the fastest possible rate."

Theory on why strange metals may exhibit LENR-like electron collisions in Bernoulli mediums.

"Low-energy nuclear reactions (LENRs), previously described as cold fusion, are hypothesized nuclear reactions that occur at or near room temperature and involve the interaction of hydrogen isotopes with metal catalysts. Unlike conventional nuclear fusion or fission, LENRs do not require high temperatures or pressures to overcome energy barriers."

In conventional aqueous solutions, heating up combustible chemicals typically increases their propensity for exothermic reactions. Cuprates, on their own, might not exhibit any characteristics that makes them volatile, like many metals or alloys are on their own. Perhaps freezing strange metals has the opposite effect on certain arrangements of synthetic metals, in that their electrons are pressured to move along the lanes not occupied by orbitals or Cooper pairs. Because they have little space to go, where they might typically form quasiparticles – when space allows – the highly structured lattice of strange metals forces the electrons to act like insulators, except they still exhibit current carrying capacity. Therefore "scale invariance" refers to the manual toggling of temperature and speed from drift velocity to signal velocity in the medium, depending only on the applied temperature. Similar to Brownian motion, the random collisions of electrons might typically cause the electrons to not travel very far in drift velocity, but due to the limited diameter of the metals, are not able to escape the non-porous edges and instead collide with one another, forming via temporary Van der Waal like interactions, a pneumatic tube, with low viscosity, and Cooper-like superconductivity, in a non-measurable anti-current (or dark current).

The applied temperature can result in anywhere between 0-50% of measured superconductance as "hidden" under the quadratic curve, and is measured as ordinary conductance once it becomes an insulator at high temperatures. This also suggests insulators, such as diamonds and glass could transfer electricity in a neutral or uncharged way, but would need a way to convert the inert lanes into encodable information (if that is the goal). In other cases, transferring something like power might require more energy to decode the low-voltage lanes than to capture a net amount, thus would be impractical.

What does one really know about Bernoulli's principle?

In fluid pressure, liquids in an enclosed medium only increase or decrease flow rate when subjected to an increase or decrease in pressure, unless the pipe's strength is less than the pressure of the water/liquid. Therefore, electrons might exhibit similar properties- They aren't strong enough to burst out of the metal, but aren't going to slow down either, because pressure seems to be independent of order, and a cardinal rule of physics is that everything should have an explanation. Just because they can't form a Cooper pair for the "express lane," they aren't going to shelter in place either. So, where *do they* go? Do they collide with themselves, and form a spontaneous microtubule-like scaffold, and transfer electrons within the lanes of atoms, until the increase in temperature causes the tubes to fall apart or dissolve and mix with the rest of the random particles "soup" with increased resistance? Knock on metal, I almost *wish* Bernoullis principle applies to the smallest electrons, because it would be less complicated than suggesting they're gliding down the metal like a mudslide or some dust storm, and then saying "the resistance says so."

I want to believe, or not.

In conclusion, while superconductors might represent an efficient way to transmit information and electricity in ultracold metals, unique arrangements of synthetic metals might be comprised of yet-to-be understood combustible microenvironments that facilitate temporary electron anti-Cooper pairs that conduct in Cooper-like pairs via van-der-Waal-like interactions, that enter a pneumatic tube-like lane that is isolated from the atomic lattices, forming "between" the existing lanes, either in an alternate dimension, similar to a bulk/batch teleportation of entangled particles, except not encoded in any specific way, unless primed or altered during initial conditions. Much like how freezing water in a pipe causes it to expand and burst, freezing metals with a unique arrangement of atoms can cause their electrons to speed up to a certain point, until they form microtubule-like quantum tunnels in a complentary BCS lane. This energy is thus “wasted” since it is not measured as current, but as resistance. Potentially converting this into usable electricity might require more input energy input than “fusion for electrons” provide. Which are also the same challenges fusion reactors face, except on a larger scale (and involving different particles).

If there is any puzzlement why I am suggesting these farfetched theories about strange metals, it’s because before the wave model, there was the luminiferous aether, and every frontier may require alternate theories to explain the simplified theories, if they turn out to be not so simple.

Discussion about this post

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