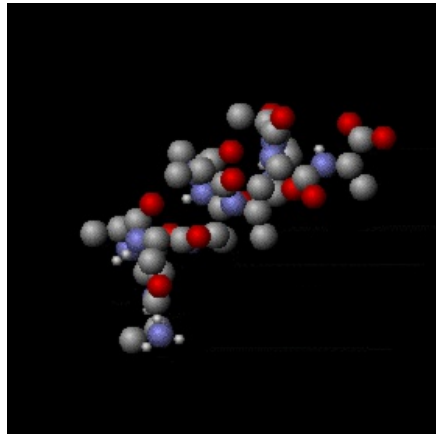


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The Drude-Sommerfeld Model

and the problem of heat capacity



by Miles Mathis

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In this paper, we will look at the free electron model or Drude-Sommerfeld model of electron transfer in elements. Although I will criticize the model harshly, and ultimately correct and extend it, it is not Drude's mechanics I will take exception to. It is only Sommerfeld's "quantum mechanical" additions, and this because they are *not* mechanical. They are only fudges, as we will find out immediately.

We can go to Wikipedia, where we find an "assumptions" sections near the top of the page. In it, we discover this:

The crystal lattice is not explicitly taken into account. A quantum-mechanical justification is given by Bloch's Theorem: an unbound electron moves in a periodic potential as a free electron in vacuum, except for the electron mass m becoming an effective mass m^* which may deviate considerably from m (one can even use negative effective mass to describe conduction by electron holes). Effective masses can be derived from band structure computations. While the static lattice does not hinder the motion of the electrons, electrons can be scattered by impurities and by phonons; these two interactions determine electrical and thermal conductivity (superconductivity requires a more refined theory than the free electron model).

Wow. Just awful. We have "effective masses," "electron holes," and "impurities and phonons." None of those nouns are physical or mechanical. They are just pushes toward data. Then we are told that superconductivity requires a more refined theory than this. I certainly hope so, though I doubt we will find any refinement from a current physics that would allow this sort of theory.

How can any physicist or scientist read sentences like that and not get nauseous? Instead of a crystal lattice, the substance becomes a vacuum. The electron mass is then allowed to vary to any extent

required, even to the extent of becoming negative. “Band structure computations” tell us how much our mass is varying. Although the electron doesn't recognize the real substance it is moving through (the actual metal, for instance), it does get scattered by impurities and phonons. Why? Because we can't match data by theorizing the metal there, but we can by theorizing imaginary particles there instead. Brilliant.

In the previous paragraph at Wikipedia, we also learn of the “screening effect.” We are told that the electrostatic field of metals is weak due to the screening effect.

Like the electric field of the nucleus is reduced inside an atom or ion due to the shielding effect, the electric fields of ions in conducting solids are further reduced by the cloud of conduction electrons.

So apparently, the electrons screen themselves. How do they do that? No answer. Clearly, the early theorists like Sommerfeld simply wanted to minimize the fields of ions, because they couldn't figure out how to solve the problem with the real fields and particles. So they got rid of the real fields by inventing screening, then solved the problem with imaginary particles and fields.

Notice they have no problem admitting this. They also create *pseudo*-potentials, which of course aren't real. The current solution relies on working backward from data to create pseudo-potentials that fit this data, and everything real is ignored to create this pseudo-potential, as we have already seen. The crystal lattice is ignored, the charge field and E/M field of the real substance is ignored, even the mass of the electron is ignored. Everything is made from imaginary particles and interactions, and all are pushed to match the needed pseudo-potentials.

All this was necessary because they didn't have a model of the nucleus, the charge field, or the real E/M field—and they still don't. All they had when these models were initially being invented and promoted was the electron, so they tried to fit everything to a field of free electrons. Drude showed that worked fairly well up to a certain point, so when it stopped working, they just pasted some imaginary math and fields on top to fill in the holes. This is what Bloch's wave is, and band structure, and so on. All of solid-state physics has been polluted by this imaginary pseudo-physics, and it was all caused by trying to build field equations without defined fields. Because Maxwell's displacement field was never physically assigned, physicists from the early parts of the 20th century had to force-fit electron fields to data, and they did this with math that became completely detached from anything real, anything known, or anything solid. Solid-state physics should long ago have been renamed fudge-state physics.

But [now that I have shown how the nucleus recycles charge](#), we don't need the pathetic Drude-Sommerfeld model anymore. We can throw out all this slop concerning imaginary phonons, changing masses, and vacuum substances, and replace it with physics. We don't need pseudo-potentials, since we can now show the real potentials.

To start with, we can show why Drude's model of free electrons moving through a lattice of real atoms worked fairly well, without any “quantum mechanical” additions. Before Sommerfeld mucked it up, the simple Drude model “provided a very good explanation of DC and AC conductivity in metals, the Hall effect, and thermal conductivity (due to electrons) in metals near room temperature. The model also explains the Wiedemann-Franz law of 1853.” Amazingly, the authors at Wikipedia even tell us why, although they don't *know* they are they are telling us why:

Historically, the Drude formula was first derived in an incorrect way, namely by assuming that the charge carriers form a ideal gas. We know now that they follow Fermi-Dirac distribution and have appreciable interactions, but

amazingly, the result turns out to be the same as Drude model because, as Lev Landau derived in 1957, a gas of interacting particles can be described by a system of almost non-interacting 'quasiparticles' that, in the case of electrons in a metal, can be well modelled by the Drude equation.

It isn't Lev Landau's quasiparticles that are matching Drude's electrons. It is my real charge photons that are doing that. Any free electrons are being driven by a sea of real photons, and this sea of photons is what we now call charge. Where the photons go, the electrons also go. But, as in the nucleus, the electrons are mainly along for the ride. It is the photons we should be tracking, not the electrons. The electrons are like buoys, signaling the charge strength and direction. But what is *determining* the field is the motion of the photons. The photon field is the real cause of everything, here and elsewhere. Since the photons interact much less than the larger ions, they act mathematically like Landau's quasiparticles. But whereas Landau's quasiparticles are virtual and heuristic, my photons are real.

The same can be said for Bloch waves. Bloch waves are imaginary waves manufactured to fit the data, and then a lot of math is created to fit free electrons to that imaginary wave. Since these old guys thought they were tracking electrons through the lattice, they thought they had to explain how electrons made it through without being scattered and without losing all kinds of energy. The only way they could do that is by letting the electron magically have a zero or negative mass at certain points, or by other hamhanded (and frankly embarrassing) tricks. But since it was always photons that were making it through and carrying the field energy, they didn't need to go to all that trouble. You don't need these tricks to show how photons pass through the lattice, since photons are around 100 million times smaller than electrons. They dodge the lattice more easily. And since charge photons are also channeling *through* the nucleus (and electrons aren't), even the photons that don't dodge the lattice also make it through.

So it is not “amazing” that “charge carriers” follow the Drude model, since these charge carriers are not electrons but real photons. As such, they do not follow Fermi-Dirac distributions or have appreciable interactions (of the sort they are talking about). As we now know, these photons have appreciable interactions only at the nuclear boundary, and even then most of these interactions are spin (magnetic) interactions, not electrical interactions. Charge photons can be redirected by channeling through the nucleus, but they cannot be stopped or slowed.

To understand this, you will have to study my nuclear papers, noting especially the way charge is channeled through the nucleus. I recommend [my latest paper on Period 4](#), which shows how transition metals channel charge through various channels, creating both electrical and magnetic conductivity. Once you understand this mechanism, you will understand both how Drude's rough model works and why it fails.

It seems to work at first because the electrons are following the photons. The electrons are moving in the photon stream, so of course they will go where it goes, in the simplest analysis. It fails because we have photons moving through the lattice to create the defining field, not electrons. Although free electrons do move through the lattice as well, their movement is not what determines through fields, either electrical or magnetic. As we saw in my analysis of a [battery circuit](#), the motion of electrons is only a side effect, one that has misled generations of physicists. To really understand the E/M field, we have to follow the photons, not the electrons. Or, to put it another way, we have to follow [Maxwell's displacement field](#), not his E/M field. The displacement field is the primary field, and it defines all greater motions and fields.

To prove this in the most efficient manner, we will jump ahead to see why the Drude model greatly

overestimates the electronic heat capacity of metals. Historically, this is why Sommerfeld had to extend and pad Drude's mechanical model with all the slop we saw above. The question was, "Given the success of Drude's model, why is the heat capacity of metals so low?" In other words, the Drude model is right about thermal conductivity, but wrong about heat capacity. Why?

The current theory explains this with *ad hoc* manipulations like screening and positive charge carriers, but the correct answer is much simpler. It has to do with historical assumptions about heat capacity, which I have now shown are false. In short, heat capacity was and still is defined in terms of quantity of substance plus degrees of freedom. But this definition of heat capacity is wrong, since it ignores charge channeling. Since charge is equivalent to heat, we may say that the historical definition of heat capacity ignored the ability of different nuclei to channel heat more or less efficiently.

In other words, current theory of heat capacity assumes that all substance is equivalent. If one substance has the same mass as another substance, it must have the same heat capacity, in the first analysis. Therefore, every alpha particle should have the same heat capacity, since it has the same mass and the same constituents. It has two protons and two neutrons, and protons and neutrons always weigh the same.

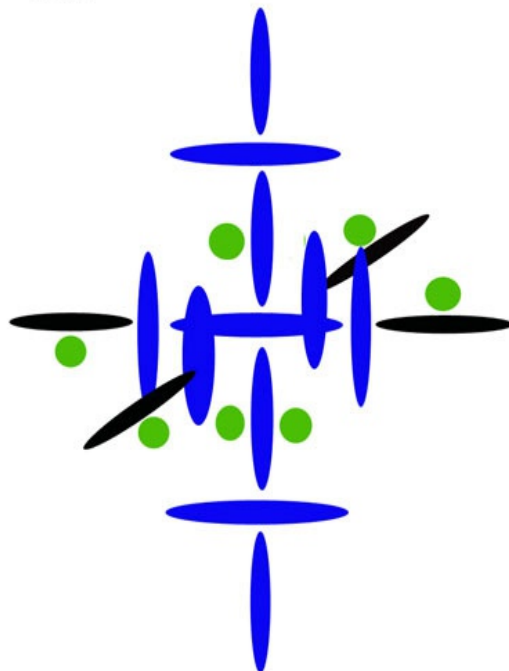
To add to this definition of heat capacity based on substance, and to round it out, current theory then allows "particles in the substance" to have various degrees of freedom, which then explain variances in heat capacity. In the animation under title, you see the wiggles and spins current theory gives to a molecule to explain heat capacity. Given this model, metals were calculated to have a heat capacity based mainly on their atomic weight. But it turns out they have considerably less heat capacity than that.

If you study my nuclear diagrams, you will see how and why this theory of heat capacity is very incomplete. Every nucleus is a definite configuration of alphas, protons, and neutrons, and this configuration creates paths that are different for each element. So each element has its own heat capacity, determined by its specific configuration. Some elements will channel more efficiently, and some less. This means that some elements will have lower heat capacities than their atomic weights would lead us to believe.

You see, current theory allows atoms and molecules to be "particles in the substance" and therefore to have various degrees of freedom. But it doesn't allow protons or alphas *inside* the nucleus to have various degrees of freedom. My diagrams show that protons and alphas in the nucleus do have variant heat capacities due to position, and this is because some positions and configurations allow for more efficient charge channeling. This variation is not really a degree of freedom in the strictest sense, since it isn't a motion of the sort currently diagrammed to illustrate "degree of freedom." It isn't a spin or wiggle, that is. It is a position in a larger configuration, and only the entire configuration explains the heat capacity.

For instance, we can study my diagram of Iron:

Iron



Each blue disk is an alpha, and each black disk is a proton. The green circles are neutrons. Now, not every alpha will have the same heat capacity in this configuration, since charge will be moving more efficiently through some than others. Charge moves through the axial level differently than it moves through the carousel level, for instance, simply due to potentials. See my previous papers for more on that. So all alphas are not the same. Nor are all protons. Protons in different positions will channel more or less charge.

And if alphas in the same nucleus are not equivalent, then alphas in different elements are even more different. Alphas have a maximum amount of charge they can recycle, but most are not near that maximum. The amount actually being recycled varies from element to element, and from position to position in the same element. This is the simple explanation of heat capacity variances.

So you see, the problem was always with the old definition of heat capacity. Metals weren't matching it because the definition was wrong. The *theory* was wrong, so the data couldn't possibly match it. All we have to do is include charge channeling in the definition of heat capacity, and the problem evaporates. Some metals have lower heat capacities than the old definition could account for, only because the old definition didn't account for charge channeling through the nucleus. Heat capacity is more closely linked to thermal conductivity than the old definitions allowed for.

In conclusion, we see once again how powerful my theory of charge channeling really is. It allowed me to penetrate this mess of the Drude-Sommerfeld model and correct it with the flip of a switch. It also allowed me to clear up this longstanding error regarding heat capacity.

I have gotten a few angry emails over the past year from “real chemists” who couldn't understand what I was up to with this big overhaul. They didn't like seeing their old equations and theories pulled apart and hung out to dry. They told me all these problems were solved long ago, and that the current theories were considered to be very successful. But I have shown once again that these theories can be

considered successful only by those who haven't looked at them closely. Yes, the current theories are extensive and they have been pushed to match a lot of respected data, but that doesn't make them successful. When you look closely at the sort of horrible pushes—both mathematical and theoretical—it has taken to match them to data, you find that contemporary physics and chemistry are not successful at all. In my studies, I have found modern science in all areas to be little more than a pile of finesses, and these finesses are not even what you would call clever. They are also not necessary, since I have shown they were always easy to correct, given a little honesty and a few hours of hard work.

To read more on this problem, you may consult my newer papers [on the Dielectric](#) and [on Anderson Localization](#).