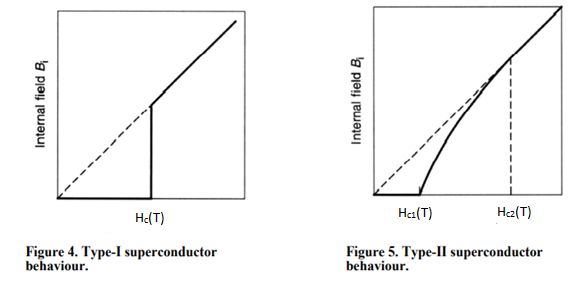
**Meisner Effect**

Now I’ll consider Type II superconductors. So as is discussed at more length in the critical fields file, these superconductors are characterized by the feature that after the first critical field boundary H > Hc1(T) is passed, flux will start to permeate the metal, increasingly, until we get to H = Hc2(T), when the external field will completely pass through. These plots below are for dirty superconductors (i.e., have impurities) I’m thinking?



So should say that Meisner effect has to do with the magnetic susceptibility, plotted above for both Type I’s and Type II’s. From the plot we see that for Type II’s, the susceptibility is χm = -1 up to a critical field Hc1. Thus they are perfect diamagnets up to that point. And imperfect diamagnets up Hc2. And as we calculate the supercurrents below, keep in mind that one could say that we’re simply calculating the magnetization, as **M** = (1/2)∫d3r **r**×**J** (see EM folder).

**Revisiting the Meisner Effect via London Theory of Superconductors**

So for Type I superconductors, all magnetic field lines are expelled from the interior. But as we said, this isn’t necessarily so for Type II’s. So let’s revisit our London Theory analysis and see how we can still postulate a non-zero superconducting electron density ns, while avoiding any consequent expulsion of all magnetic field lines. Actually, we’ll find that it was our assumption that ns was position-independent that resulted in the unavoidable conclusion that B was attenuated (therefore, expelled). So let’s repeat the analysis from before, but this time, relaxing that one assumption. We start with the current, basically kinematics, equation:



where this time we suppose that just a portion, ns, of the total electron density, n, is superconducting (am presuming we eliminate the last term, ‘cause we’re keeping our analysis restricted to small currents?) and our Maxwell equations:



Again, instead of using the current kinematics equation to solve for jind in terms of E, we’ll do the reverse, and plug into the third equation. Like we did in the previous file, we’ll also neglect the EM wave generating term in the fourth equation, to presume we’re keeping things in equilibrium. And then we have for the third ME equation:



and fourth equation,



Working on the top equation (3rd Maxwell),



Then we might specify the time-independent constant to be 0, as we did before, for superconductors, so that,



Turns out our ansatz for jind that we used in the Type I file will also work here,



where for us, φ would again be just some unknown function. Can see this ansatz works below:



And then to proceed, we could combine this with the bottom (4th Maxwell) equation, in the metal’s interior, and say,



We can write it this way, FWIW,



So now we have a source term in our Laplacian equation, which means **B** doesn’t have to exponentially (or at all) damp inside the material. But we can see that if we eliminate spatial variations in ns, our equation reduces to the Type I guy. Being very loose with this, a cylindrical column of undamped **B** penetrating the metal in the z-direction, would be consistent with a radial ns gradient (ns starting from 0 at center of column and increasing to average ns density by column’s edge) say, and a radial **j**ind gradient (current circulating about the z-axis, with magnitude increasing from 0 at center of column to average jind by column’s edge). This is evocative of vortices that the **B** field forms when penetrating the metal.

**Revisiting Meisner effect via BCS theory of Superconductors**

So we can revisit our analysis of Type I conductors. Starting with H, we have:



where A is the vector potential, and jp the paramagnetic current density,



And from the Metals/Impurities/Nonequilibrium/Conduction/Quantum file, we derived the relationship:



(no ∇φ option here I guess) I’ll call the thing in brackets, **K**(q,ω).



And then we have an equation of the same form as the London equation. And so we can equate,



So the Meisner effect is destroyed if we presume ns is spatially dependent. That’s consistent with our formalism here. If we presume **K**(q,ω) is dependent on q, then ns will be too. And of course it will be spatially dependent then. To work out what K(q,ω) is we merely have to repeat our Type I calculation and not take q → 0. But not gonna bother.