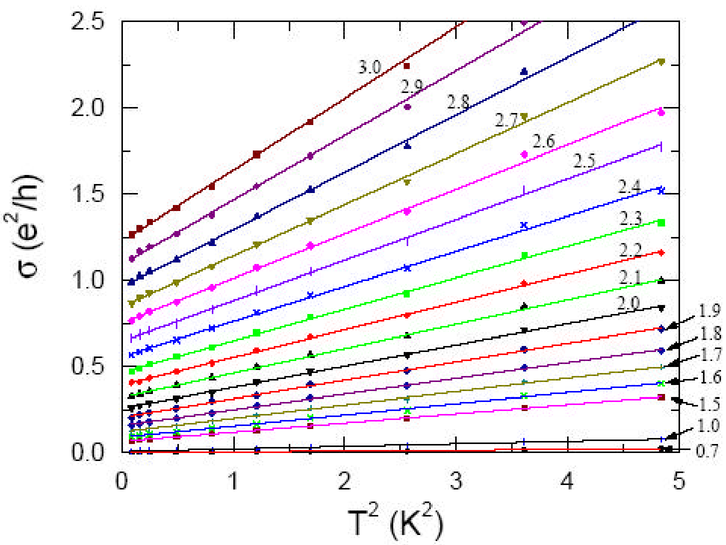
Homework Assignment #6 - Solution

Section 2

We are trying to fit the data of conductivity as function of temperature of the form:

$$\sigma(T) = \sigma_0(n, T = 0) + mT^{\alpha}. \tag{1}$$

With the use of $\alpha = 2$, the dependence of conductivity on T^{α} is linear, i. e. we get straight lines as plotted in the following figure:



Section 3

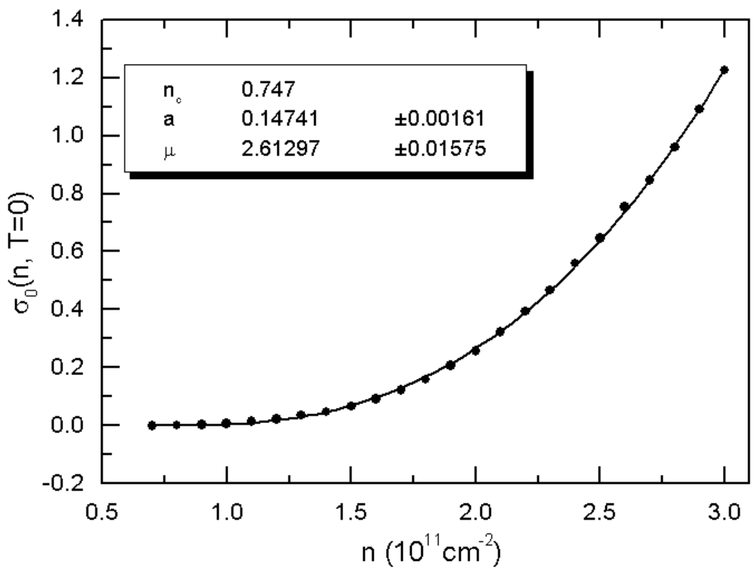
The fitting results for the previous section also gives us the following table for the conductivity σ_0 extrapolated to $T = 0$ corresponding to different densities n used:

n	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
σ_0	-5.38e-4	5.94e-4	0.00352	0.00787	0.0141	0.0235	0.0356	0.0472	0.0672	0.0908
n	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
σ_0	0.123	0.159	0.208	0.258	0.322	0.394	0.467	0.559	0.646	0.754
n	2.7	2.8	2.9	3.0						
σ_0	0.847	0.961	1.09	1.22						

As we expect that:

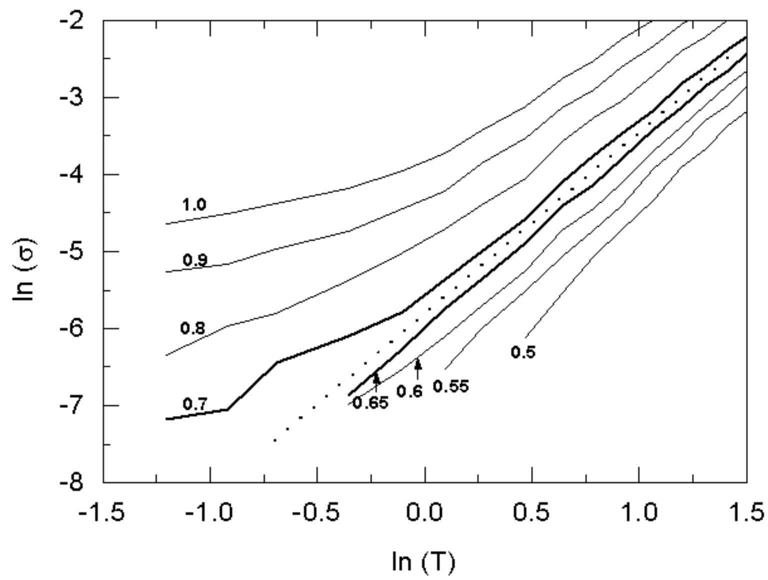
$$\sigma_0 = a(n = n_c)^{\mu}, \tag{2}$$

one can find $a = 0.147, n_c = 0.747, \mu = 2.61$. The figure showing this fitting is presented as follow:



Section 4

As we found $n_c = 0.747 \times 10^{11}\mathrm{cm}^{-2}$, we will focus on the data with densities around this value. The following figure shows that the curves $\sigma(T)$ on the log-log plot will be straight at the density n_c located somewhere between two values $n = 0.65 \times 10^{11}\mathrm{cm}^{-2}$ and $n = 0.7 \times 10^{11}\mathrm{cm}^{-2}$.

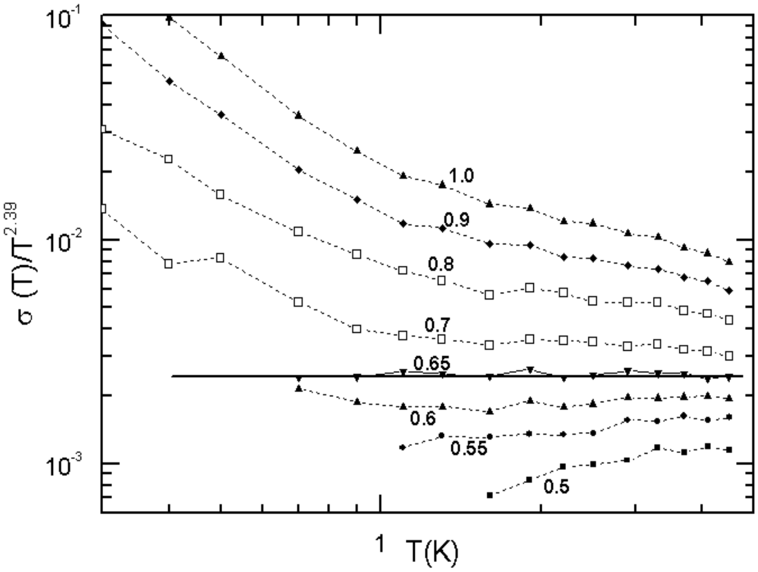


This value of n_c *may* be considered to agrees with the value $n_c = 0.747 \times 10^{11}\mathrm{cm}^{-2}$ found in the section (3). In order to continue our work for the next sections, let's choose $n_c = 0.65 \times 10^{11}\mathrm{cm}^{-2}$. At this density, we can extract $x = 2.39$.

Section 5

In order to plot $\sigma(T)/\sigma_c(T) \sim \sigma(T)/T^x$ on a log-log scale, we choose $n_c = 0.65 \times 10^{11}\mathrm{cm}^{-2}$. At this point, as described previously, we got $x = 2.39$. The figure shows that the curve corresponding to the critical density $n_c = 0.65 \times 10^{11}\mathrm{cm}^{-2}$ is horizontal. All the curves with $n < n_c$ curve down at $T \to 0$ corresponding to the insulating phase, while all the curves with $n > n_c$ curve up at $T \to 0$

indicating the metallic phase.



Section 6

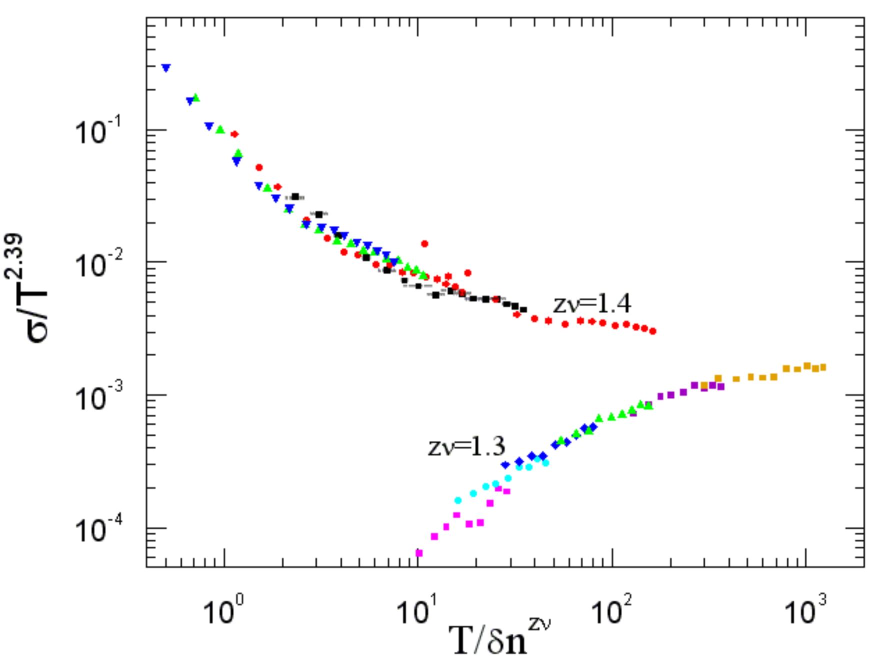
Using the data obtained for the section 5 and the assumption that:

$$T^*(n) \sim \left(\frac{|n-n_c|}{n_c}\right)^{\nu z} = \delta n^{\nu z}, \tag{3}$$

we can find the values of $n\nu$, at which all the conductivities collapse onto a scaling function f, i.e.:

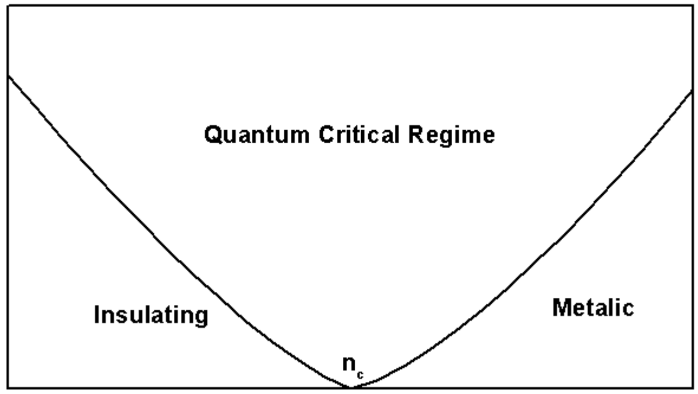
$$\sigma(n,T) = \sigma_c(T) f\left(\frac{T}{\delta n^{\nu z}}\right). \tag{4}$$

The following figure indicates explicitly the collapse mentioned above.



Section 7

The $T^*(n)$ is plotted in the $n - T$ phase diagram as follow:



Section 8

With the assumption (3), in the section 6 the exponent $\nu z = 1.4$ for metallic regime, and $\nu z = 1.3$ for insulating regime.

Section 9

In the section 4, we found $x = 2.39$ while in the section 6 and 8 we found $\nu z = 1.4$. Therefore, t the conductivity exponent is

$$\mu = \nu z x = 3.346. \tag{5}$$

This value *may* be considered to agree with $\mu = 2.61$ estimated in the section 3.