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Defects in BCS-Theory/
Why a theory of High-Temperature-Superconductivity can`t be successful (at now) ?

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Dear Sir,
naturally you must not read the following article. Sixty years the theory of solids has survived with a defective theory of High-Temperature-Superconductivity. For an explanation of conventional superconductivity the BCS-theory in their usual form is enough , although it isn`t correct. But for searching a theory of **High-Temperature-Superconductivity**, it`s necessary to start with correcting the BCS-theory. Naturally you are able to search and find the mistakes in the BCS-theory by yourself. But it`s more economical spending 60 minutes of time for reading, than waiting 30 years (or longer) for the necessary inpiration.
Much pleasure during reading will be wished by

(H. Ch. Haunschild)

Defects in BCS-Theory of superconductivity

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And now some considerations, that shall not be unmentioned:

I) There is no influence of Coulomb-repulsion on Tc

A correct theory of superconductivity doesn`t contain any term belonging to the Coulomb-repulsion of electrons. Naturally the paired conductance-electrons are repulsing each other. But the Coulomb-

interaction also appears in the free-electron state with the same strength. The volume containing one Cooper-pair contains dozends to billions of other conduction-electrons. As soon as the paired electrons make way for the Coulomb-repulsion of their pairing-partner, they will enhance the Coulomb-repulsion by other electrons in the surrounding. The mean-value of repulsion always leaves the same. The paired electrons are not able to discriminate, if the repulsions belongs to their pairing-partner or to other electrons.

In the equations due to Tc the Coulomb-repulsion only can appear, if it`s increasing by pairing. **This portion** of Coulomb-repulsion, appearing likewise in the free electron-gas **and** in the bounded state has no influence on Tc and has to be neglected in all calculations of critical temperature. This consideration is appliable to conventional SC and the HTSC likewise. The size of the effective dielectrical function in all equations of Tc is: Dielectrical function **without** attractive correlation subtracted from the dielectrical function **with** attractive correlation:

$$\varepsilon(SL) \propto \frac{1}{V^*(m.WW)} - \frac{1}{V^*(o.WW)} = \frac{1}{V^*(SL)} \propto \varepsilon(SL)$$

Using $\frac{1}{V^*} \propto \varepsilon_0 \varepsilon(\omega)$ we will get:

$$\varepsilon(SL) = \varepsilon_0 \cdot \varepsilon(\omega) - \varepsilon_0 = \varepsilon_0 \cdot \left[\varepsilon(\omega) - 1\right]$$

In all simple metals with their electron-phonon-interaction is appliable: $\varepsilon(\omega) = 1 - \frac{\omega_D^2}{\omega^2}$

For that it`s available for the dielectrical function:

$$\varepsilon(SL) = \varepsilon_0 \cdot [1 - \frac{\omega_D^2}{\omega^2} - 1] = \varepsilon_o \cdot \left[- \frac{\omega_D^2}{\omega^2} \right]$$

Consequently is following for the matrix-element of pair-formation V*:

$$V^* = \frac{1}{Vol. \cdot (q^2 + k_{TF}^2)} \cdot \frac{e^2}{\varepsilon_0 \cdot \left[- \frac{\omega_D^2}{\omega^2} \right]} \propto \omega^2 \propto (\hbar\omega)^2$$

By that the strength of the interaction = V* is quadratic proportional to the kinetic energy $\hbar\omega$ exchanged between the paired electrons. The higher $\hbar\omega$, the higher will be Tc.

The magnitude of V* only depends from the **attractive** interaction. The Coulomb-**repulsion** doesn`t appear. Apparently in the theoretical limit $(\omega \to \infty)$ Tc can go across the Debye-

temperature. Regrettable, the reality is different. This contradiction shall be solved in the following chapter.

II) Increasing of kinetic energy in superconducting state

By all means it is accepted, that in the pairing state the kinetic energy of the paired electrons is higher than the Fermi-Energy. Really this increasing of kinetic energy isn`t denied in BCS-Theory, but in spite of that it is not regarded in their equations. A correct theory of SC must take regard on this circumstance, otherwise it rests uncompletely. In case of HTSC the BCS-equations are leading to totally worthless results. That doesn`t mean a total worthlessness of BCS-theory. But it`s necessary to complete it: By BCS-theory **[1]** the Self-consistency-equation (SCE) runs as:

$$\frac{V}{2}\cdot\sum_{k}\frac{1}{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}}\cdot\tanh\frac{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}}{2k_BT}=\text{One}$$

Changing from summation to integration it`s necessary to integrate about all these kinetic energies ε_k , which can be occupied by all paired electrons. By BCS-Theory the above integration-limit is the Debye-Energy and the below integration-limit always is fixed at zero. Really the below integration-limit is $\varepsilon_k^{Min}=\hbar\omega$. This $\hbar\omega$ means that kinetic energy, which will be exchanged by the electrons within one pair.

Prove: For pair-building the conduction-electrons must be scattered in states above the Fermi-Energy. The same (well-remarked, **the same**) virtual phonons, intermediating the pairing are also responsible for scattering these electrons in states above the Fermi-edge. By that the energy exchanged between the paired electrons is the same like that, which they are possessing additionally to their Fermi-energy without electron-phonon-interaction. The virtual scattering-energy, accepted above the Fermi-energy, and that virtual energy, which is exchanged between the paired electrons are really identical. This additional kinetic energy will be nominated as $\hbar\omega$ (how it is already

remarked above).

Therefore the kinetic minimum-energy ε_k^{Min} is not the energy zero (respective Fermi-Energy minus chemical potential), but that energy virtual exchanged between the paired electrons. For that reason the below integration-limit in the SCE is not zero, but the energy $\hbar\omega$.

That`s why the SCE runs as:

$$\int_{\hbar\omega}^{\hbar\omega_D} \frac{d\varepsilon_k}{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}} \cdot \tanh\frac{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}}{2k_BT_C} = \frac{2}{D(E_F)V^*}$$

In this formation the SCE can`t be solved. Halfway useful is dividing the SCE in two parts:

$$\left(\int_0^{\hbar\omega_D} \frac{1}{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}} \cdot \tanh\frac{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}}{2k_BT} - \int_0^{\hbar\omega} \frac{1}{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}} \cdot \tanh\frac{\sqrt{\varepsilon_k^2+\Delta_{SC}^2(T)}}{2k_BT} \right) = \frac{2}{D(E_F)V^*}$$

If T = Tc, all Cooper-pairs are broken, that means $\Delta(T_c) = 0$.

With $X = \frac{\varepsilon}{2k_BT_C}$ results: $\frac{2}{D(E)V^*} = \int_0^{\frac{\hbar\omega_D}{2k_BT_C}} \frac{\tanh x}{x}dx - \int_0^{\frac{\hbar\omega}{2k_BT_C}} \frac{\tanh x}{x}dx$

Under supposition, that $\hbar\omega_D$ and $\hbar\omega \gg k_BT_C$ the SCE can be solved for Tc:

$$k_BT_C = \frac{1{,}14\cdot(\hbar\omega_D - \hbar\omega)}{\exp\left(\frac{2}{D(E_F)V^*}\right)}$$

In difference to the BCS-result the nominator is decreasing linearly with increasing energy-exchange $\hbar\omega$.

<u>Remark 1:</u> By that corrected formula the Tc-Maximum will be reached at $\omega \approx \frac{\omega_D}{1{,}3}$ (derivating of Tc by the kinetic energy $\hbar\omega$) and the maximum critical temperature in simple metals amounts to:

$$T_C^{MAX} = 1{,}14\cdot(1-0{,}77)\cdot\Theta_D\cdot\exp(-1{,}3^2) \approx 0{,}05\Theta_D$$

By that in conventional SC`s the maximal possible Tc only amounts to five percent of the Debye-temperature. This results by setting the coupling-constant and the density of states a bit arbitrarily as one. Doubling the coupling-constant or the density of states, we will get:

$$T_C \approx 1{,}14 \cdot 0{,}45 \cdot \Theta_D \cdot \exp\left[-\frac{(1{,}45)^2}{2}\right] \approx 0{,}18\Theta_D$$

Remark 2: Really $\hbar\omega$ can go to zero in the theoretical limitation. But in that case V* is zero also. That leads to an unlimited exponential-function and a critical temperature of zero.

Remark 3: Superconductivity will disappear, when $\hbar\omega > \hbar\omega_D$.

Remark 4: These consideration are valid also in regard of the magnitude of the SC-energy-gap:

$$\Delta_{SC}(0) = \frac{\hbar\omega_D - \hbar\omega}{\sinh\left[\frac{2}{D(E_F)V^*}\right]} \approx 2(\hbar\omega_D - \hbar\omega) \cdot \exp\left[\frac{2}{D(E_F)V^*}\right]$$

When the energy $\hbar\omega$ exchanged between the electrons gets higher than the Debye-Energy, the increase of kinetic energy will be higher than the decrease of the potential energy, destabilizing the pairs. Numerical the critical temperature and the SC-energy-gap will be negative in this case.
The SC-energy-gap will reach their maximum, when $\varepsilon_k = \hbar\omega = 77\%$ of the Debye-energy.
Therefore even just not at the value ε_k = zero.
That maximum-contribution will be measured as energy-gap. All other contributions are smaller and are resigning back of that maximum-contribution.

III) Resume

In conradiction to BCS-Theory the Coulomb-repulsion **doesn`t** appear in the formula for Tc. On the other hand in this article is taken regard to the circumstance that in the pairing state the kinetic energy always is higher than the kinetic energy without electron-phonon-interaction, respective the Fermi-Energy. To the essential reduced the Tc-equation runs as:

$$T_C \propto \frac{\hbar\omega_D - \hbar\omega}{\exp\left[\frac{1}{D(E_F)} \cdot \frac{\omega_D^2}{\omega^2}\right]}$$

In case of very small or very big values of $\hbar\omega$ the Tc-values are approximating to zero. In between a maximum appears. Drawing the critical temperatures in dependence of $\hbar\omega$ results a parabolic-

similar graph. Drawing the critical temperatures of High-Tc-superconductors in dependence of doping (i. e. in dependence of the kinetic energy of the holes) also appears a parabolic-similar curve. Unarbitrarily one is wondering wether there is any connection.

All these considerations are not included in BCS-Theory. Distinctively a quantitative explanation of High-Tc-Superconductivity is not available at now. In every half-way satisfying explanation of HTSC these considerations shall have to be regarded. Otherwise one can search so long for a theory of HTSC, till one will turn black.

And now I`m begging for your statement by the E-Mail-Adress in the headline:

A) I cannot find any mistake in your scientific paper, but you must have made some, otherwise you would be right really.

B) Your first mistake is on page …. in line …. In consequence your demonstration is worthless.

C) I cannot find any mistake, probably you`re right. I prefere publishing.

D) Because of lack of professionalism I cannot make anything with your work.

Thanks for responding.