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On the Nature of Unusual Microwave Response of Thin FeSe1-xTex Film Near Critical Temperature

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FORMULATION OF THE PROBLEM. Recently we reported about appearance of the X-band microwave (MW) effective surface resistance peak at $T \leq T_c$ when plotted as function of T of thin $FeSe_{1-x}Te_x$ film (x=0.7) at parallel orientation of the MW magnetic field of the resonator near the surfaces of a thin film **[1].** For the explanation the authors suggested the idea of the changing orientation of the MW magnetic field in the film at S-N phase transition. If the idea is true, the effect should depend on the film orientation in a resonator. **Therefore it was naturally to study the surface impedance of $FeSe_{1-x}Te_x$ film as function of T at different orientations of the film in the MW resonator.**

[1]. A.A. Barannik, N.T. Cherpak, Y. Wu, S. Luo, Y.-S. He, M.S. Kharchenko, A. Porch, *Low Temperature Physics,* vol. 40, no 6, dx.doi.org/10.1063/1.4881178, 2014.

Experimental technique and details

Detailes:

Sample under test: $FeSe_{1-x}Te_x$ film (x=0,5) of 100 nm thickness, substrate: single crystal CaF2 of 0.5mm thickness

Resonator with a "hot finger": sapphire hollow cylinder in metal screen (T=4.2K), Fig. 1

Operation mode: H011

Temperature range: 3 – 22K

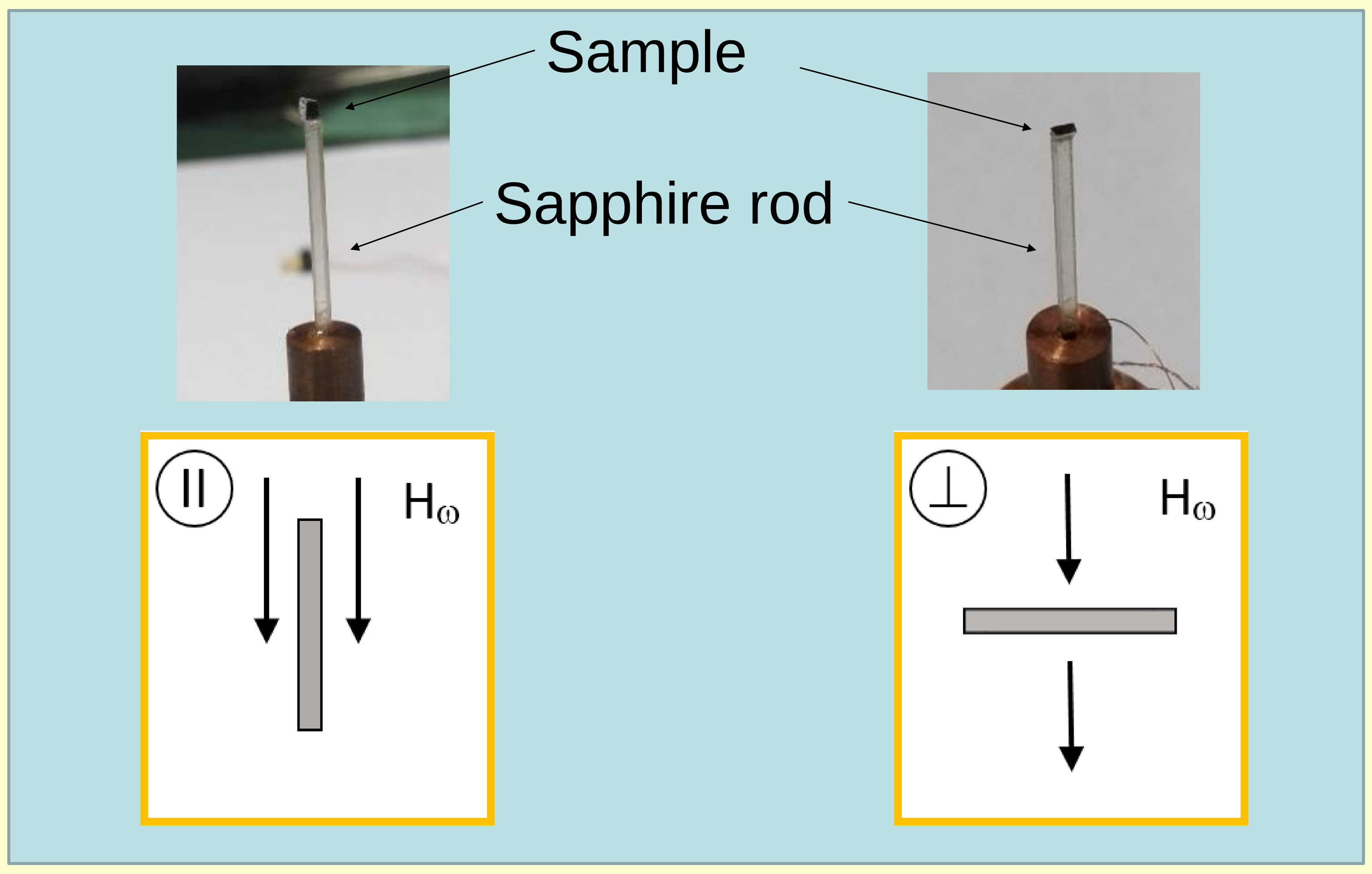


Fig.1. Parallel (II) and perpendicular (⊥) orientations of the FeSeTe film in MW Hω field of the resonator.

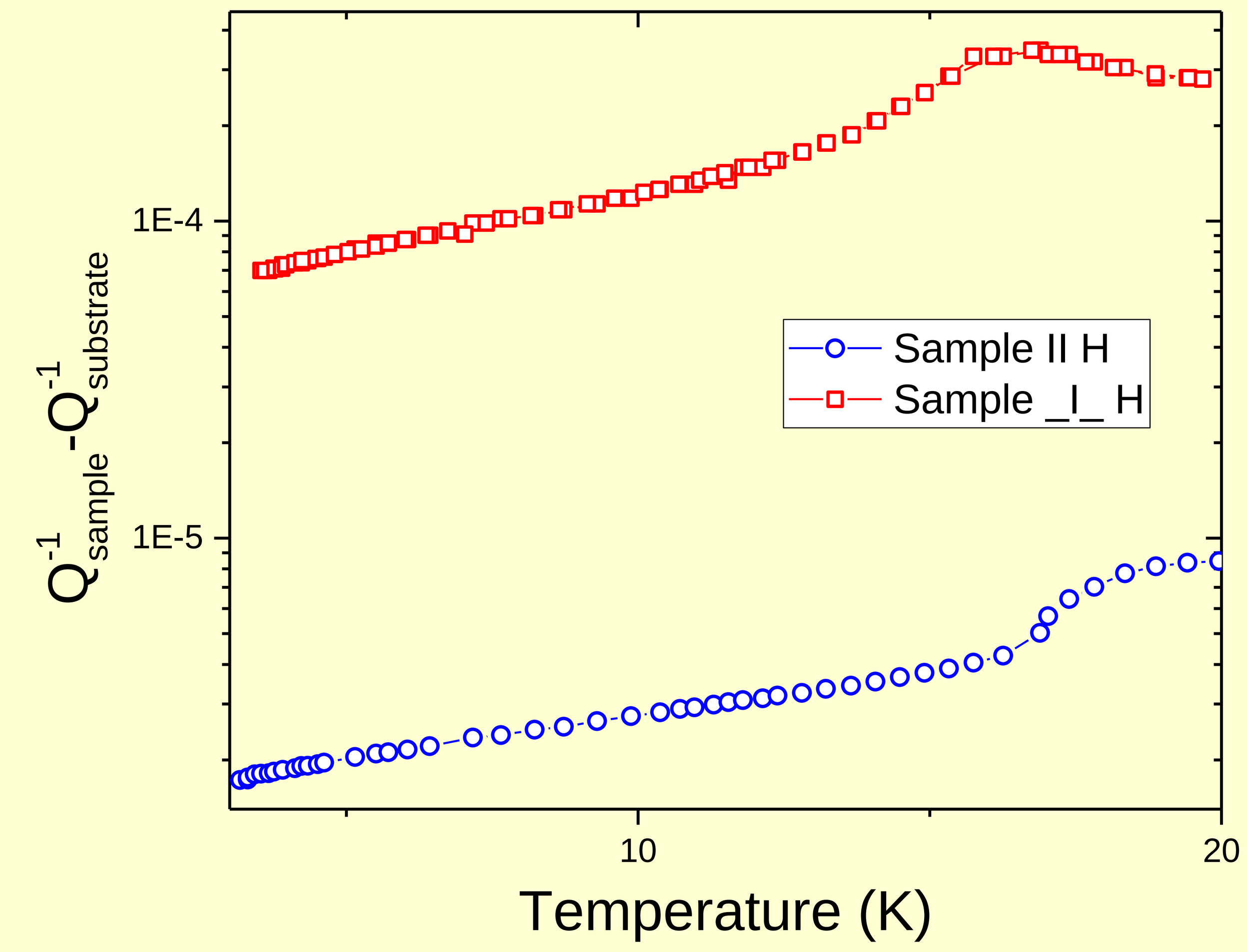


Fig. 2. Inverse Q-factor corresponding to MW loss in superconductor for parallel (II) (blue) and perpendicular (⊥) (red) orientations of the FeSeTe film.

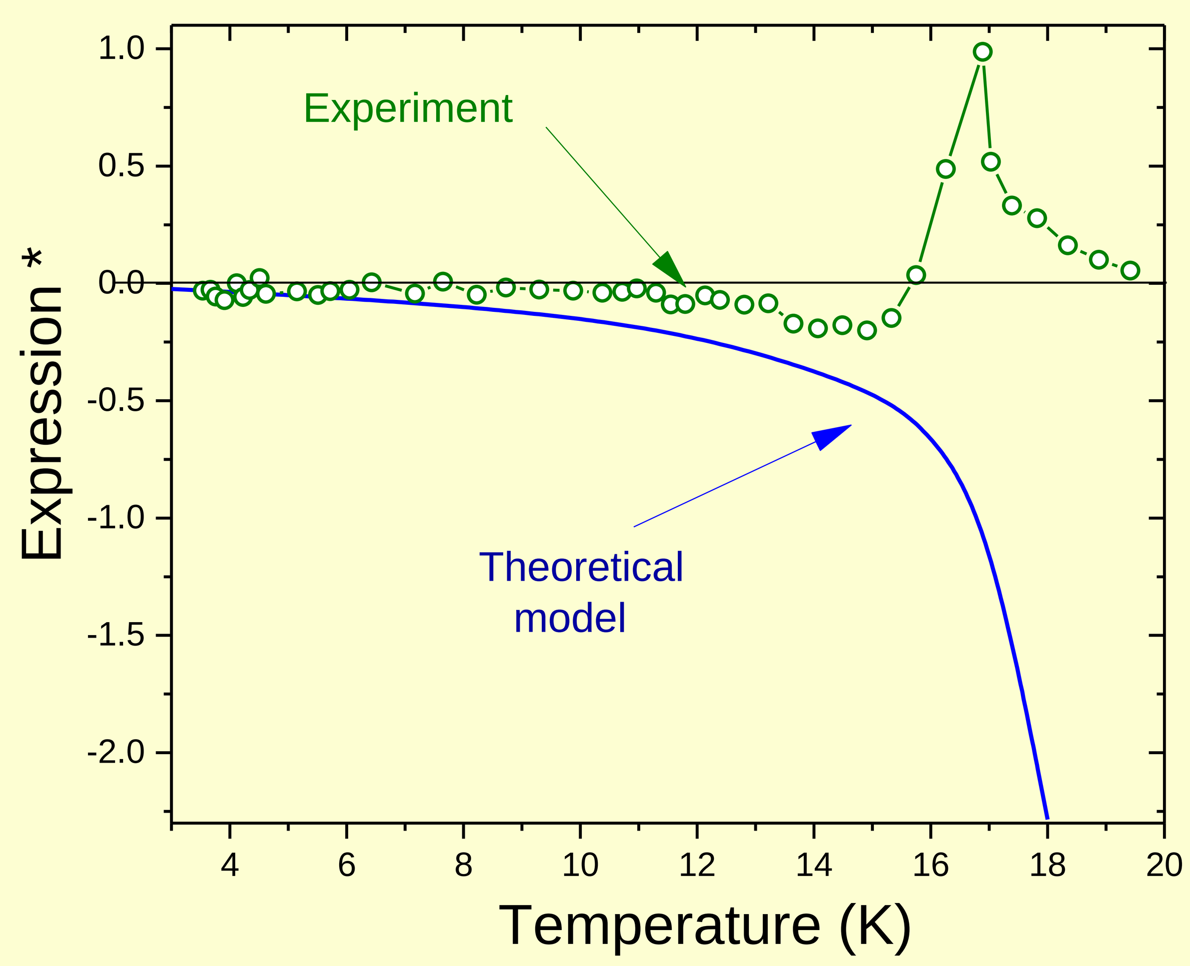


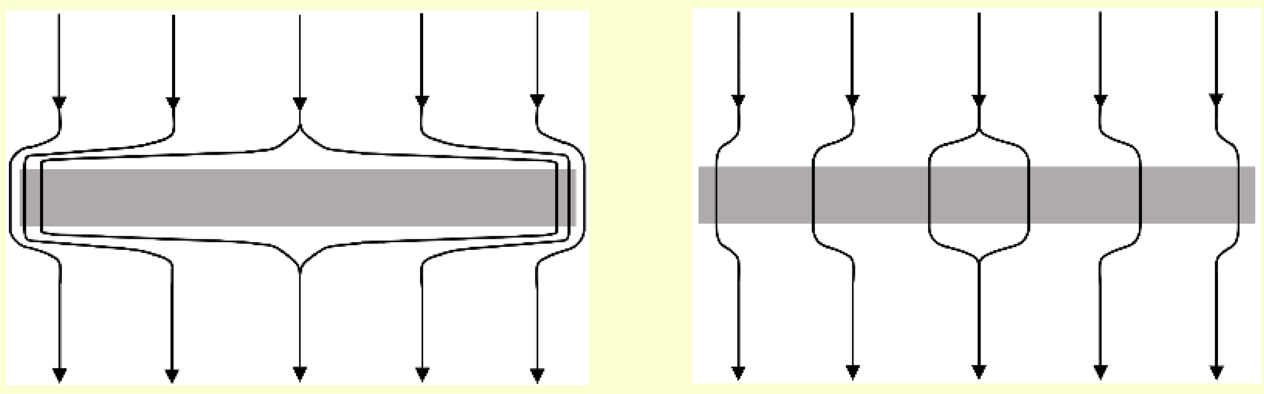
Fig. 3. Comparison of theoretical model with $A_s^{\perp}$(T)-const and experimental data.

$$Q_s^{-1} = Q_{sample}^{-1} - Q_{substrate}^{-1} = A_s R_s^{eff}$$

Under assumption $A_s^{\perp}$ is independent on T:

*) $$\frac{1}{Q_{s\perp}^{-1}}\cdot\frac{dQ_{s\perp}^{-1}}{dT} - \frac{1}{Q_{sII}^{-1}}\cdot\frac{dQ_{sII}^{-1}}{dT} = \frac{2\gamma}{T}\cdot\left(\frac{T}{Tc}\right)^{\gamma}\cdot\frac{1}{1-\left(\frac{T}{Tc}\right)^{\gamma}};\qquad \lambda_L^2(T) = -\frac{\lambda_L^2(0)}{1-\left(\frac{T}{Tc}\right)^{\gamma}}$$

The left side of *) is based on measurement data in Fig.2, the right side is calculated using models of Z_s^{eff} for II and ⊥ cases (see Fig.1 and [1]).



a) b)

Fig. 4. Distribution of Hω field with the film at (a) $T \ll T_c$ and (b) $T \leq T_c$ (qualitative presentation).

Conclusion:

The observed feature of Q(T) and effective $R_s^{eff}(T)$ of thin SC film at ⊥ resonator Hω field near the film surfaces and $T \leq T_c$ can be explained by changing orientation of MW magnetic field within the film when T rises to T_c.