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ILLINOIS INSTITUTE OF TECHNOLOGY

# *Further Evidence for Localized Magnetism in the Surface Oxides of Nb.*

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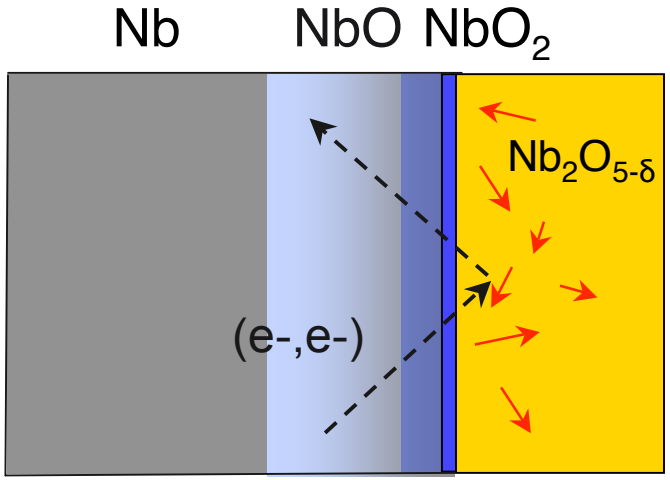
* Funded by DOE (ANL, FNAL)

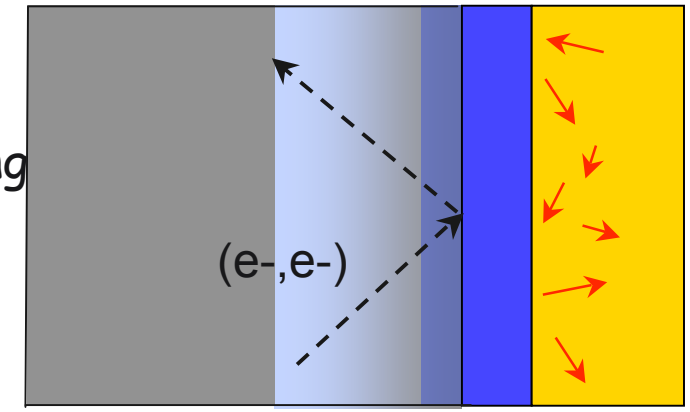
# How the mild baking effect can reduced the magnetic scattering?

Before baking




- Defected Insulator $Nb_2O_{5-\delta}$
- Peierls semiconductor $NbO_2$ (0.1eV)
- Metallic $NbO$-$NbO_X$

After Mild baking




Baking makes blocking layer
(Stoichiometric $NbO_2$ $Nb_2O_5$)

*M.Delheusy et al. APL 92, 101911 (2008); Q.Ma, J.W.Freeland et al. J.Appl.Phys.96 7675 (2004)*

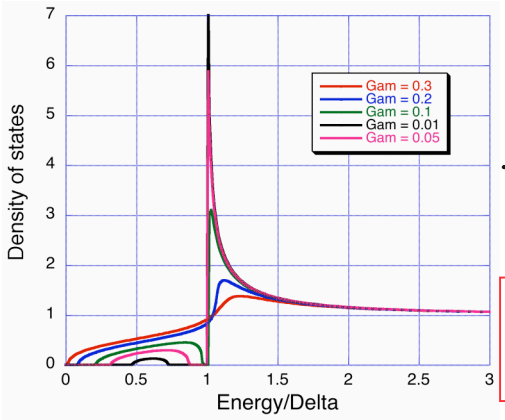
# Origin of the broadening?

→ Proximity effect
Poisoned layer
} Reduced gap value

→ Inelastic tunneling -> Add to conductance

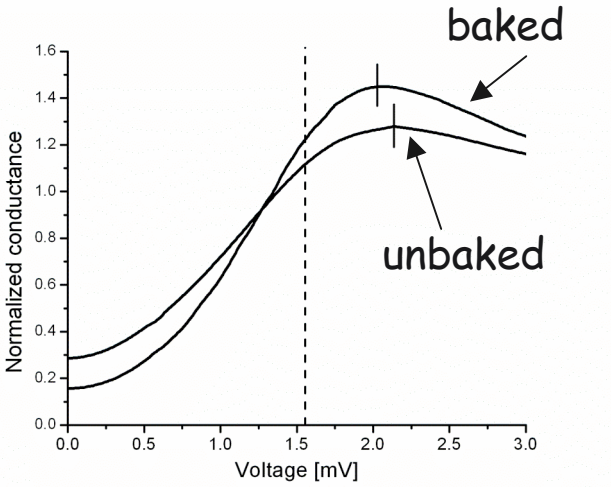
→ Strong coupling effect -> Dynes model
Only for T~Tc

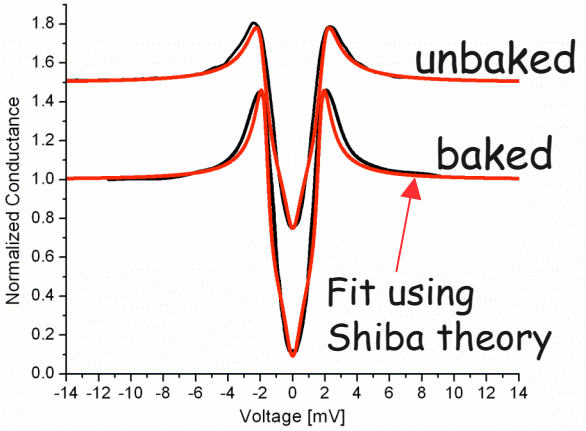
→ Magnetic scattering -> Shiba model ✓




{ α = Γ/Δ Pair breaking
{ ϵ quasiparticule states

Baked Nb Crystal Shows reduced Magnetic scattering



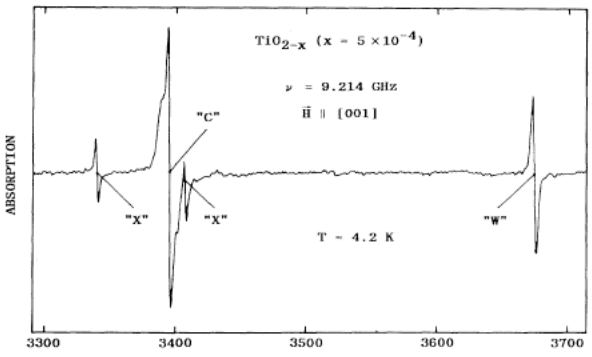



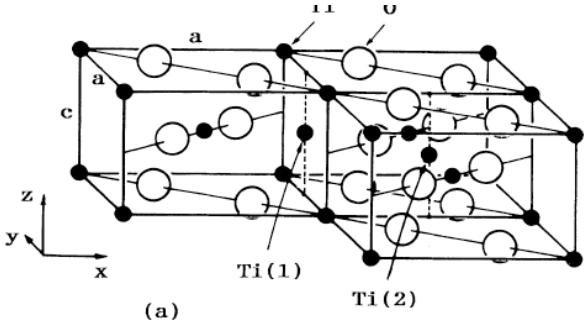

Unbaked: Δ=1.5 meV, α=0.3, ϵ=0.6
Baked: Δ=1.55 meV, α=0.17, ϵ=0.6

*H.Shiba. Prog.Theo.Phys. 50 (1973), A.A.Abrikosov,L.P.Gorkov Sov.Phys. JETP 12 (1961)*

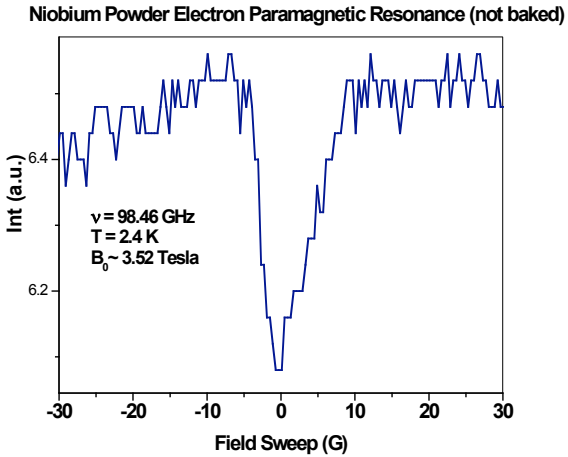
# EPR and Magnetic Susceptibility

Aono, Hasiguti
PRB 48, 12406 (1993)



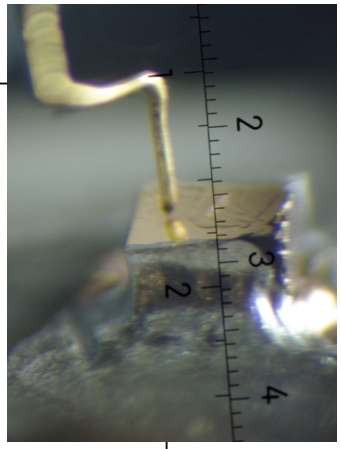

{121} defect




g = 1.96

Nb(4+)

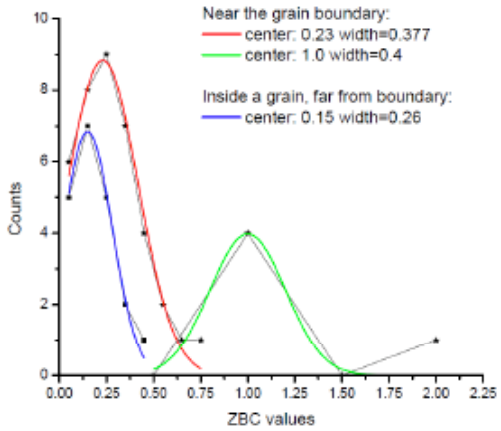
# Nb cavity coupons (G. Ciovati)



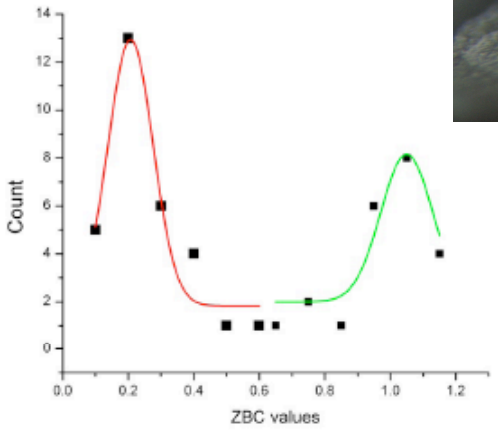
## Hot-Cold Spots

### Hot spots:

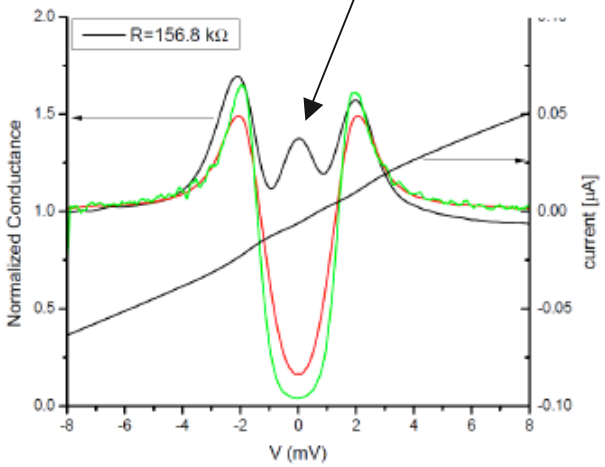
Sample 9




Sample 10




ZBC

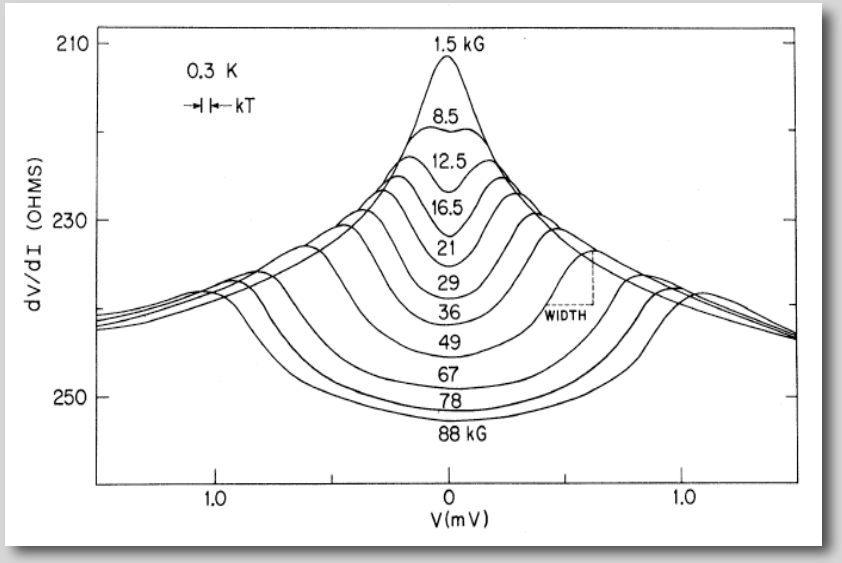


# Zero Bias Conductance (ZBC) Peaks
# Spin Flip Tunneling

PHYSICAL REVIEW B VOLUME 5, NUMBER 2 15 JANUARY 1972

**Zero-Bias–Conductance-Peak Anomaly of Ta-*I*-Al Tunnel Junctions at 0.3 K and 90 kG**

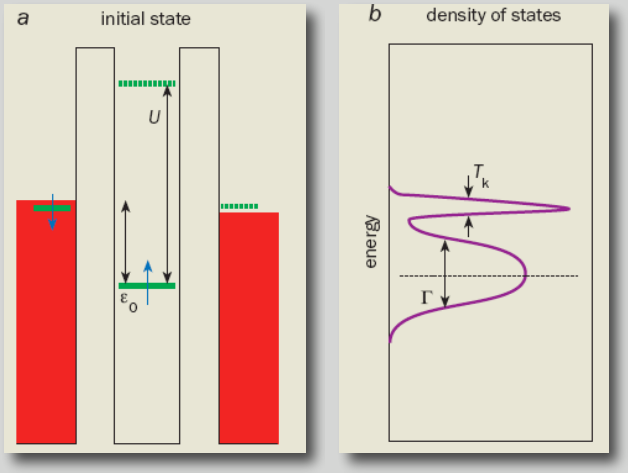
Joel A. Appelbaum and L. Y. L. Shen
*Bell Telephone Laboratories, Murray Hill, New Jersey* 07974



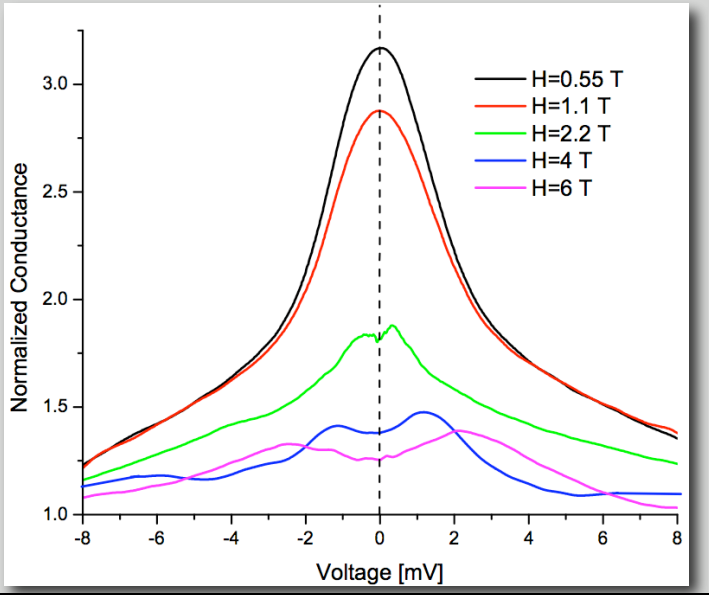

Zeeman Energy = $g\mu_B H$

$g$ = 1.8

## Kondo Resonance

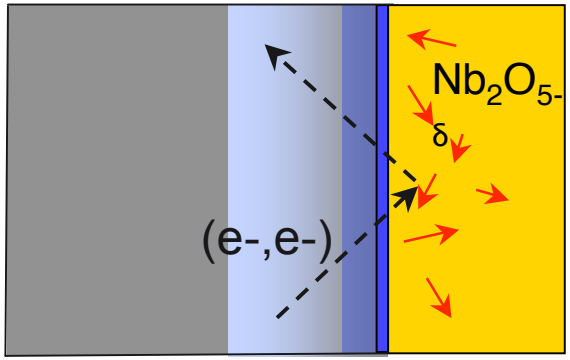


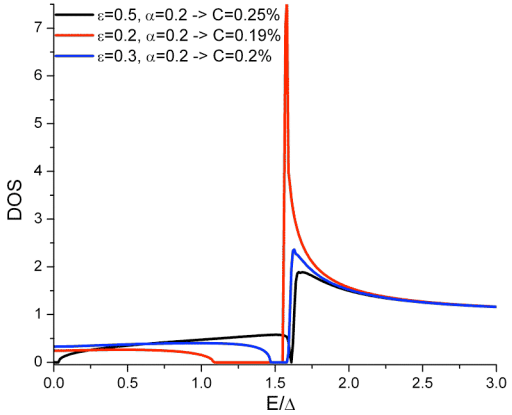

## Nb/$Nb_2O_5$/Au (hot spot)

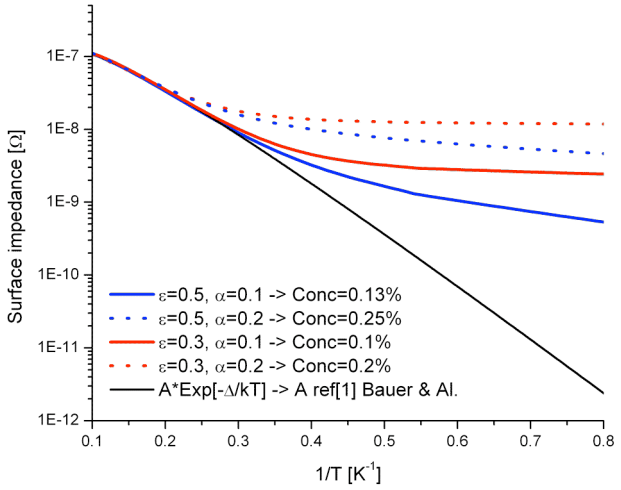


# Modeling of RF Surface Impedance

(Maxim Kharitonov, ANL)



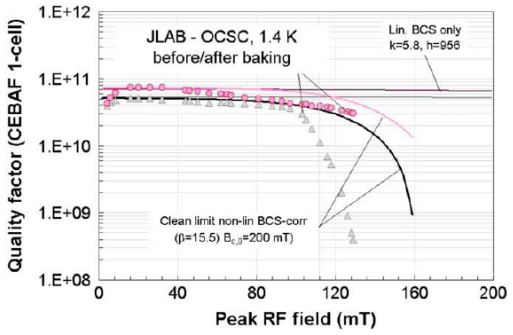




Physica C 441 (2006) 51–56

Evidence for non-linear BCS resistance in SRF cavities ☆,☆☆

P. Bauer [a,*], N. Solyak [a], G.L. Ciovati [b], G. Eremeev [c], A. Gurevich [d], L. Lilje [e], B. Visentin [f]



## *Summary*

- •PCT is revealing the bulk Nb gap ~1.55 meV
- •Clear evidence of magnetic scattering
- • EPR and ZBC peaks
- • Explanation of residual RF resistance

## *Future Work*

- • Transport EPR of Nb films
- • Planar junctions (low T, High H, weld pits)
- • Co-planar waveguides (Zeeman splitting)
- • STM of defects