Coexistence of superconductivity and magnetism in $NdO_{0.5}F_{0.5}BiS_2$: A muon spin relaxation/rotation study

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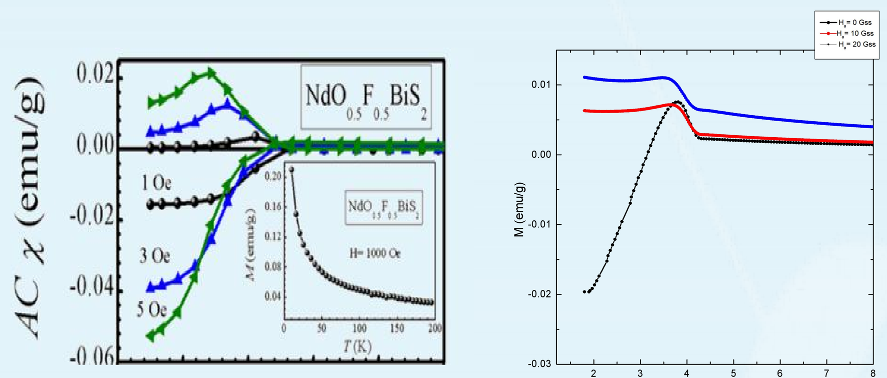
Motivation

- Traditionally, superconductivity and long–range magnetism had been considered mutually exclusive . In recent years, the relation between magnetism and superconductivity has aroused a lot of interest. Since it was reported there is a positive bulge of magnetic susceptibility around 4.9K in the FIG. a , which indicate there may be a relation between superconductivity and magnetism in this compound $NdO_{0.5}F_{0.5}BiS2$.
- The structure of BiS2 based layered compounds are similar to that of high Tc cuprates and Fe-pnictides. So it may help us understand the mechanism of superconductivity in high-Tc superconductors.

a



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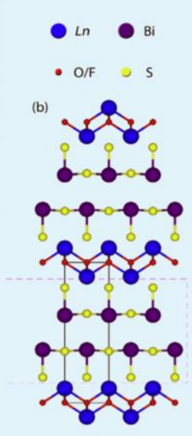


- **FIG. a.** : **Left figure**:AC magnetic susceptibility plots for $NdO_{0.5}F_{0.5}BiS_2$ *(quoted from:D. Yazici , et al. Physica C 514 (2015) 218–236)*
- **Right figure**: DC magnetic susceptibility plots measured by our group.
- **FIG. b.** : Schematic unit cell of $NdO_{0.5}F_{0.5}BiS_2$ compound.*(quoted fromD. Yazici , et al. Physica C 514 (2015) 218–236)*

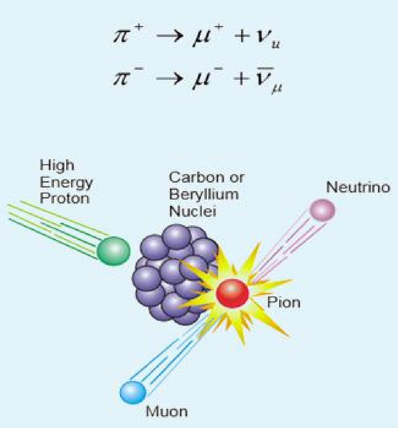
$TF\_\mu SR$ experiments

The number of decay positrons recorded per time bin in each counter could be given by:

$$N(t) = N0e^{-t/T\mu}[1+AP(t)+B]$$

Muon Lifetime: 2.19714μs

c



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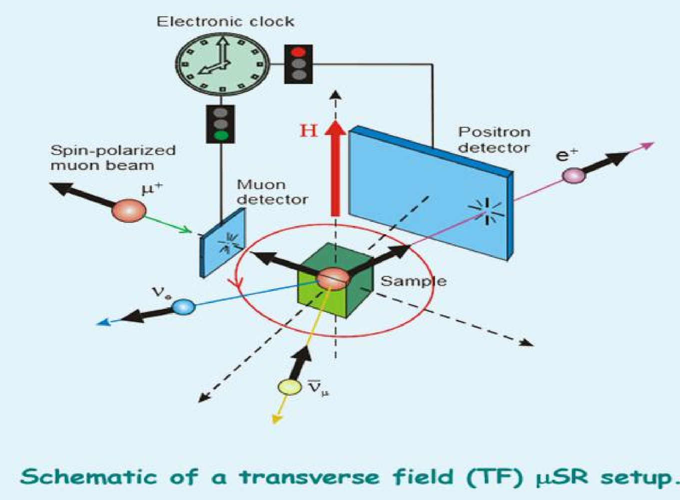


For a type-II superconductor with a *flux line lattice(FLL)* ,the muon spin depolarization rate is shown below:

$$\sigma_{sc} = \gamma_{\mu} \Delta B_{rms}$$

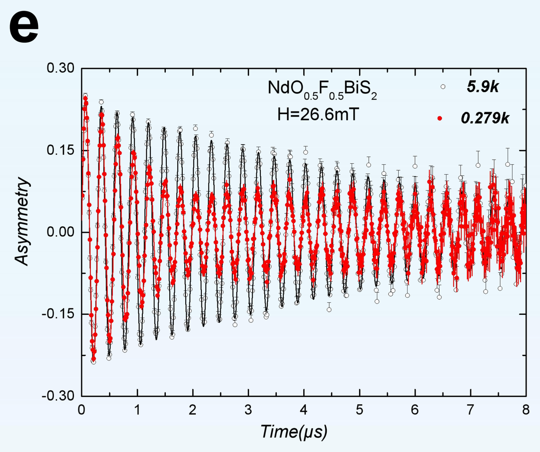
where ΔB_{rms} is the rms width of the internal field distribution in the *FLL*. ΔB_{rms} is approximately related to the penetration depth λ_{ab} by :

$$\Delta Brms = 0.172\frac{\phi 0}{2\pi}(1-b)[1+1.21(1-\sqrt{b})^3]\lambda_{ab}^{-2}$$

Where $\phi_0 = 2.068\times10^{-15}$ Wb is the magnetic flux quantum and b = $B/B_{c2} \approx H_T/H_{c2}(T)$.

Result

e



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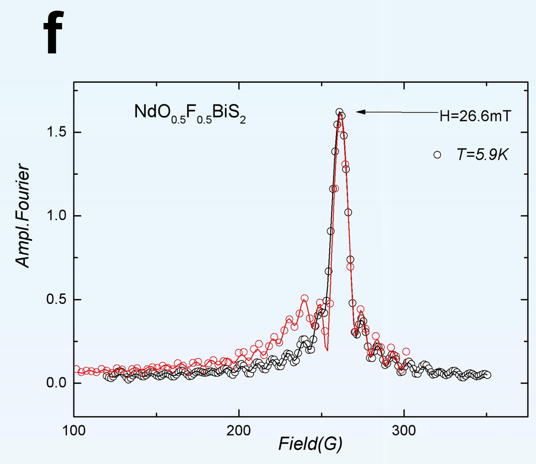

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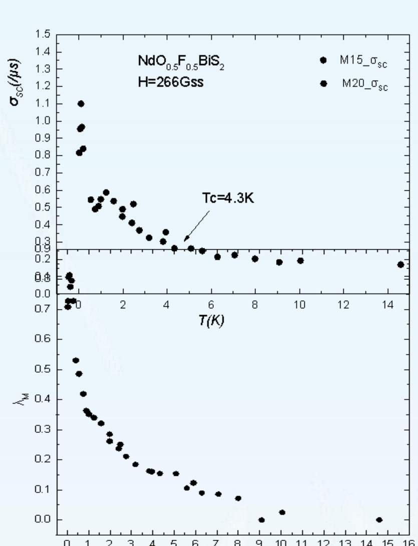
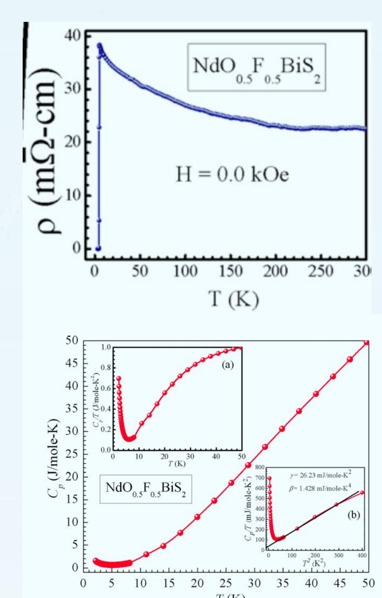


- **FIG. e.** : Time evolution of symmetry at normal sate(black line) and SC sate(red line).
- **FIG. f.** : There is a field shift at around 244 mT which is induced by meissner effect.
- **FIG. g.** :The figure above shows the rate of gaussian term in the fitting formula, while the figure below shows the rate of exponential term.
- Fitting function $P_{TF}(t) = A_1 e^{-\frac{1}{2}\sigma^2 t^2} e^{-(\lambda_M)t}\cos(\omega_1+\varphi_1) + A_2 e^{-\lambda_{BG}t}\cos(\omega_2+\varphi_2)$
- The two additive terms represent the superconducting part and the background part respectively. Parameter A_1 ,A_2 represents the initial asymmetry of each part. The gaussian term is induced by ***FLL (flux line lattice)*** and exponential term is generated by the magnetic part.
- The data in **FIG.g** shows an abnormally large jump at around 1k, which may indicate there is something interesting at 1K.

h



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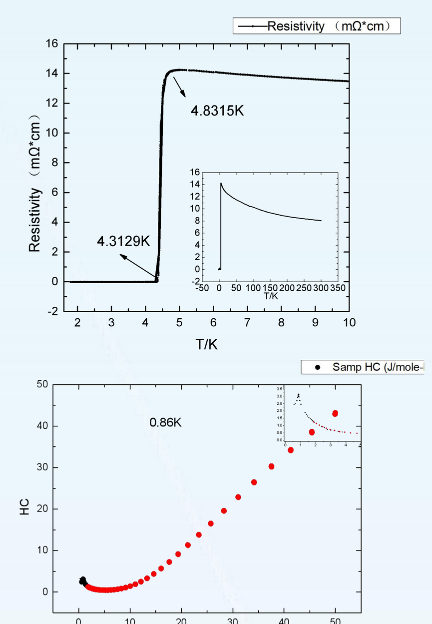

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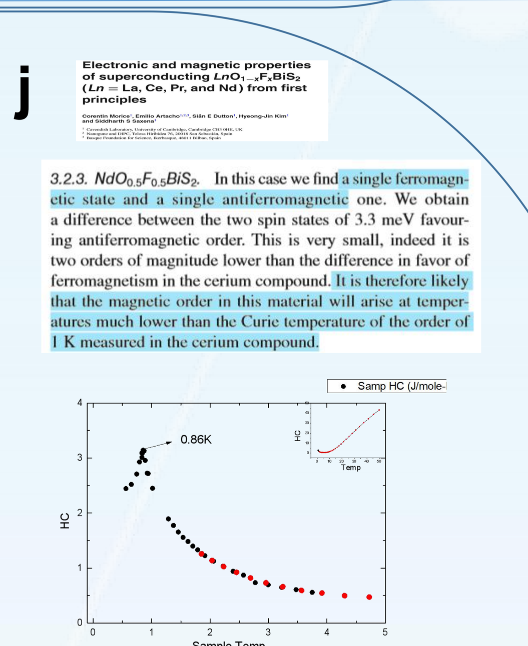

- **FIG. h.** :The reported resistivity and specific heat properties cited from *Rajveer Jha et al. JOURNAL OF APPLIED PHYSICS.*
- **FIG. i.** : The resistivity and specific heat properties measured by our group.
- **FIG. j.** :First principles calculation suggest that ordered magnetism may appear at temperatures below 1k. And the figure below shows the data of heat capacity we measured below 1K.

- From the data above, our data fit well with others. And this is the first time that a possible magnetic phase transition has been observed at low temperatures (below 1K). We still need to do further measurements to make sure which phase transition it is.
- The DC data in **FIG.a** shows there is a positive bulge appeared with SC transition, which may indicate that there is competition for structural phase transitions

Conclusion

- The data showed perfect conductor properties and the meissner effect. Its transport properties agree well with others.
- This is the first time that a possible magnetic phase transition has been observed at low temperatures (below 1K). But we still need to do further measurements to make sure which phase transition it is.
- The DC data indicate that there may be a competition for structural phase transitions .

Acknowledgement

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