# High-Field Study of the Electrical Transport of Nanostructured $Bi_3Ni$ at Very Low Temperatures

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## Introduction

While bulk $Bi_3Ni$ is nonmagnetic and superconducting below $T_c$ = 4 K, in nanostructured $Bi_3Ni$ superconductivity emerges in coexistence with ferromagnetic ordering [1]. The magnetic properties of various $Bi_3Ni$ samples, obtained by novel chemical reaction paths, have been investigated before in static and pulsed magnetic fields. During our stay at the NHMFL we focused on transport measurements of nanostructured $Bi_3Ni$ samples, in order to determine the phase diagram and the magnetoresistance behavior.

## Experimental

We performed ac transport measurements on 1 mm long needle-shaped $Bi_3Ni$ supercrystals (see Fig 1. inset). The supercrystals consist of bundles of nanometer-sized $Bi_3Ni$ fibers with the c-axis along the needle. We measured the temperature and orientation dependency of $H_{c2}$ using a lock-in amplifier and a top loading $^3$He cryostat with rotator insert and conducted the experiments in a 31 T magnet in Cell 9 of the DC field facility.

## Results and Discussion

The experiment carried out by transport measurements show that in contrast to bulk $Bi_3Ni$, superconductivity in confined $Bi_3Ni$ is still present in high magnetic fields even well above the simple Pauli-limiting field $\mu_0 H_P$ = 7.36 T using $\mu_0 H_P/T_c$ = 1.84 T/K. By taking the midpoint of the transition the largest critical field was obtained at T = 0.35 K ($H$ II c) with $\mu_0 H_{c2} \approx$ 19 T. This indicates that $H_{c2}$ at $T$ = 0 K is almost three times larger than $\mu_0 H_P$. The round shape of the angular dependent measurements around $\Theta$ = 90° (Fig. 1) demonstrates that the 3D anisotropic Ginzburg-Landau-Theory is applicable; deviations might be explained by small misalignment.

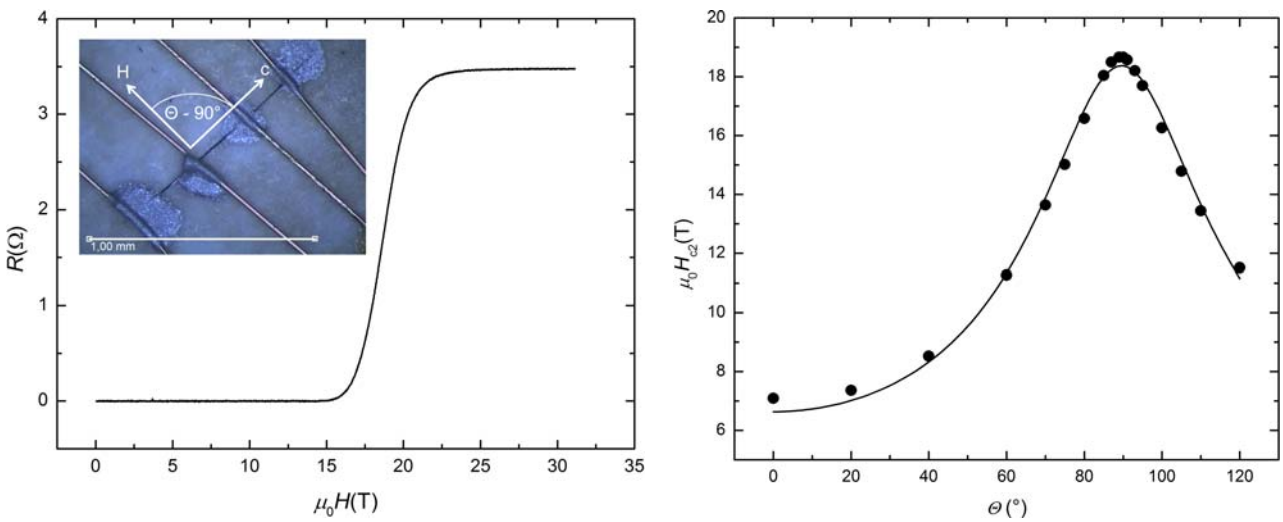


Fig 1: Left: Field dependency of the resistance of nanostructured $Bi_3Ni$ at $T$ = 0.35 K and $\Theta$ = 90°. Right: Angular dependency of $H_{c2}$ at T = 0.35 K (dots), the line represents a fit using 3D anisotropic Ginzburg-Landau-Theory.

## Conclusions

The results show a strong enhancement in the upper critical field of $Bi_3Ni$. This might be explained by strong spin orbit coupling. However, spin-triplet pairing in this nanoscaled structures is likely, since an internal field due to the formation of ferromagnetism is also present. A manuscript is in preparation.

## Acknowledgements

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## References

[1] Herrmannsdörfer, T., *et al.*, Phys. Rev. B, **83**, 140501 (2011).