# PL1-INV

## Real space imaging of the superconducting vortex lattice: Recent results and prospects

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I will review vortex lattice imaging using scanning probe microscopes and discuss recent prospects. First, I will discuss the behavior of vortex lattices in tilted magnetic fields. Many practical applications of high Tc superconductors involve anisotropic materials and magnetic fields applied on an arbitrary direction. The shape and properties of vortices in titled magnetic fields is largely unknown and I will discuss the insight won about vortex properties and manipulation by imaging experiments in several anisotropic superconductors [1,2]. I will also review vortex distributions at very high magnetic fields and make a comparative discussion of results in the new 1144 family of pnictide superconductors[3]. I will finally make the point about new techniques in achieving atomic scales measurements of the Josephson effect using superconducting tips and recent (and rather serendipitous) insight into the shape of the superconducting transition[4,5].

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[3] Influence of multiband sign-changing superconductivity on vortex cores and vortex pinning in stoichiometric high-Tc CaKFe4As4, A. Fente et al., Physical Review B **97**, 134501 (2018); Superconductivity and vortex lattice in the hedgehog magnetic phase of Ni-doped CaKFe4As4, J. Benito et al, in preparation; On hyperuniform distributions of superconducting vortices, J. Benito et al, in preparation.
[4] Low frequency AC oscillations in superconductor-superconductor atomic size tunnel junctions, V. Barrena et al, in preparation.
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## PL2-INV

# Superconducting Magnet Development for Next-Generation Accelerator Capabilities

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The physics needs of particle accelerators have pushed the boundaries of superconducting magnet technology from their initial implementation in the Tevatron through the current High Luminosity Upgrade project for the LHC. Potential future machines like the FCC, ILC, or the CEPC will require the development of even more advanced magnet technology. Current state of the art $Nb_3Sn$ magnets are unable to meet the needs of future colliders both from a cost and performance standpoint, so teams around the world are working to define the needs and develop the technologies needed to meet the aggressive requirements of future accelerators. Everything from the conductor through the design and construction of magnets will need to be re-thought to ensure that future accelerators will be feasible. Current roadmaps on how this development may play out, along with the magnet needs for future accelerators and technologies under development to meet these needs will be presented.

Keywords: Accelerators, Superconducting Magnets, High temperature superconductors, Nb3Sn

## PL3-INV

### Advanced SQUID instruments for mineral exploration

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Quantum magnetometers, say magnetic field sensors with quantum limited resolution, have the potential to develop significant impact on applications in geo- and environmental science such as mineral exploration, geo-engineering and geo-technical tasks like pipe line detection or unexploded ordnance detection and archaeometry. Especially, mineral exploration has a high social priority to enable a sustainable and affordable supply of the high technology industry with the required materials.

Within this talk, we will give a short and limited introduction on the geophysical methods which make use of highly sensitive magnetometers, herein Superconducting Quantum Interference Devices (SQUIDs), and the according specific demands on them. In order to make use of their extreme resolution in mineral exploration, the magnetometers themselves have to overcome two main challenges – they must be operable at Earth's magnetic field without degradation of their performance especially in terms of signal resolution and, often for active methods, have to be able to track fast changing signals with large amplitude.

The two main methods in geophysics for SQUID magnetometers, namely magnetics and electromagnetics will be discussed in more detail. We will introduce instruments which are able to map magnetic field anomalies with utmost resolution in order to derive 3D distributions of magnetization or conductivity of sub-surface geological structures. We will provide examples form mineral exploration and archaeology.

Within the second method, a secondary magnetic field induced from currents in the sub-surface has to be recorded with high resolution and bandwidth for determining the conductivity and polarization effects of the according geological structures under investigation. We will provide examples of ground based transient electromagnetics and will discuss the future prospects of SQUIDs in this context.

Finally, we will discuss which research topics have to be addressed to widen the range of applications for SQUIDs in geophysics.

Keywords: Quantum magnetometers, SQUID, Magnetometry, Magnetics, Electromagnetics, Gradiometry, Transient electromagnetics

## PL4-INV

# Development of $(Ba,K)Fe_2As_2$ tapes and wires in Japan

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Among various iron-based superconductors, $(Ba,K)Fe_2As_2$(Ba-122) are potentially useful for high field applications due to their high upper critical fields of over 50T and small anisotropy. However, enhancements of superconducting properties are still needed to boost the successful use of Ba-122 in such applications. In this presentation I will review recent progress of Ba-122 conductors in Japan.

Ba-122 tapes and wires are prepared by *ex situ* PIT method using Ag as a sheath material. The application of uniaxial pressing at the final stage of deformation significantly enhances $J_c$ values. However, the uniaxial pressing is not a practical method for long tape fabrications. Furthermore, the Ag sheath is completely annealed and becomes very soft after the heat treatment. In order to solve these problems a combination of new sheath structure of stainless steel(SS) and Ag-Sn alloy double sheath are used. The highest $J_c$ value of SS/(Ag-Sn) double sheathed tapes reaches $1.4\times10^5$A/cm$^2$ in 10 T, 4.2K for cold pressed tape. Even for rolled tapes, the $J_c$ reaches to the practical level of $10^5$A/cm$^2$ in 10T. More interestingly, the heat treatment temperature can be greatly reduced for these double sheathed tapes.

Recently ~1m long Ba-122/SS/(Ag-Sn) double sheath tape with fairly uniform $J_c$ distribution was fabricated. Bending tests of the double sheath tapes were also carried out. $J_c$ started to decrease at the bending diameter of 30mm which corresponds to bending strain of ~0.17% in Ba-122 layer. These results demonstrate that the double sheath is promising for making long Ba-122 tapes for high magnetic field applications.

Superconducting joints for Ag sheathed mono-filamentary Ba-122 tapes were fabricated. Two wires were inserted into Ag-Sn alloy tube from both ends, uniaxial pressure was applied to the joint and the joint was heat treated. $J_c$ at the joint was $1.7\times10^4$A/cm$^2$ at 4.2K and 10T.

Generally, round wire superconductors are more useful than tape conductors. However, Ba-122 round wires show much lower $J_c$ values than the tape conductors due to lower Ba-122 mass density. Application of hot isostatic pressing(HIP) is effective in improving mass density and $J_c$ values. However, the $J_c$ of HIP processed wires still remains low level compared to the tape conductors. Further improvement of $J_c$ capacity is required for Ba-122 wires.

Keywords: mass density, sheath material, critical current density, superconducting joint

## PL5-INV

### Frontiers of $Nb_3Sn$ wire technology

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65 years after its discovery, $Nb_3Sn$ still defends its leading place against HTS in high field applications, like high-resolution NMR spectrometers, fusion magnets and laboratory magnets, and has even regained interest over the past decades pulled by the next Big Science experiments. In particular, the Future Circular Collider at CERN represents the next big potential application as well as a grand challenge for $Nb_3Sn$ superconductors. The goal of a 100 TeV proton-proton collider set by the high-energy physics community has led to a baseline configuration requiring dipoles generating 16 T in a 100 km tunnel. This translates into a requirement of a minimum critical current density of more than 1'500 $A/mm^2$ at 16 T and 4.2 K, which is substantially beyond state-of-the-art for commercial $Nb_3Sn$ wires. Apart from high critical current density, the stress sensitivity of $Nb_3Sn$ is a parameter of the highest importance for the design of the next generation accelerator magnets, whose large sizes and intense fields will result in unparalleled electromagnetic forces. The aim of this talk is to illustrate the directions in which these technology needs are driving the properties evolution of $Nb_3Sn$. First, I will introduce the main parameters controlling the achievable transport current density in $Nb_3Sn$. Emphasis will be given to some recent innovations showing that the potential of the material for future performance upgrades is not yet exhausted. I will also report on what we learned regarding the mechanisms of the wires' irreversible critical current degradation upon mechanical loading and discuss possible strategies towards high-performance $Nb_3Sn$ wires with enhanced stress tolerance.

## PL6-INV

### ISEULT, a Whole Body 11.7 T MRI magnet

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The Iseult project is a French-German initiative focused on very high magnetic-field molecular imaging. That project includes a Whole Body 11.7 T MRI magnet that will equip Neurospin, a neuroscience research center operating at CEA Saclay since November 2006. After 7 years of fabrication at Belfort by GE Power, the Iseult magnet was delivered to CEA in June 2017 and its connection with the cryoplant and with all the ancillary equipment was completed in October 2018. After 4 months of cooldown and 4 months of tests, the Iseult magnet has reached its nominal field of 11.72T for the first time, on July 18th.