EMP European Microkelvin Platform

1. Project Basics

Specific heat of dilute alloys of holmium and silver

Project Title

ECHo

Group Name

2. Personal

2 a) User Group Leader

Prof. Dr. Max Mustermann | 1957-09-01 | m

Name | Date of Birth | Gender

email@provider.com

Email | Phone

senior scientist | Condensed Matter Physics

Position | Scientific Field

Kirchhoff-Insitute for Physics

Affiliation

curriculum vitae

Education and Awards:

- Master of Science (Mars University, 1980)
- PhD in Physics (Mars University, 1984)
- Habilitation (University of MadeUpCity, 1990)
- Young Researcher Low Temperature Award (1985)

Employment

- Junior Researcher (Mars University, 1980-84)
- Senior Researcher (Mars University, 1984-86)
- Senior Researcher (Institute for Low Temperature Physics, 1986-92)
- Professor for Solid State Physics (Institute for Low Temperature Physics 1992-now)

Selected Publications (75+ in total):

- Publication 1: doi:xyz
- Publication 2: doi:xyz
- Publication 3: doi:xyz
- Publication 4: doi:xyz

2 b) Group Members

Marie Musterfrau	1978-01-23	f
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Email	Phone	
junior scientist	Condensed Matter Physics	
Position	Scientific Field	
Kirchhoff-Insitute for Physics		
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3. Project Description

In this project, we will investigate dilute alloys of holmium and silver in order to determine the impact of their specific heat on the performance of the micro-calorimeters of the neutrino mass experiment ECHo. In particular, we focus on alloys with atomic Ho-concentrations of 1E-2 to 1E-4 at temperatures between 1mK and 700mK. Our experimental approach relies on the well-established relaxation method and the micro-structured setup itself will be optimized for the planed temperature range. With the help of these data, we will evaluate and refine empirical models allowing us to optimize the Holmium content in the neutrino mass experiment ECHo. Measurements will be conducted by Mr. Max Mustermann, who has a great expertise in the field of heat capacity measurements. To our knowledge, cryostats at UHeidelberg are capable of hosting these experiments and already have the proper wiring needed to perform the experiments.

4. Scientific Objectives

Ho-163 is used by various experiments (e.g. ECHo, Holms) to extract the electron neutrino mass. This is being done by precisely measuring the energy spectrum of the electron capture process 163Ho --> 163-Dy by means of micro-calorimeters operated at mK range. It is crucial to understand the impact of Holmium ions embedded in the sensor material of these micro-calorimeters on the performance of the detectors, namely on the heat capacity. First results have already been published results (see doi:abc/xyz) and indicate a strong influence of the concentration-independent hyperfine and crystal field splitting. However, at even lower temperatures the dipol-dipol and RKKY interaction start to play an important role leading to concentration-dependent heat capacities. To this end, the proposed project can help to further deepen the understanding of those interactions of dilute Ho in silver. This will eventually allow us to design the ECHo experiment such that the energy resolution can be optimized with respect to holmium concentrations and operation temperature. If time allows, further host materials such as gold and aluminium shall be investigated as well.

5. Technical Objectives

The experiment consists of a cupper cylinder of roughly 2cm diameter and 9cm in height, which is magnetically shielded by a superconducting Nb wrapping. One face side of the cupper cylinder is used to attach the experiment to the experimental platform of the cryostat (M3-screw). On the other face side, three micro-structured chips are placed that are needed to perform the experiment: The first chip ('heat capacity chip') hosts the sample under investigation. The sample will be attached by diffusion welding allowing for a good electronic thermal contact to the heat capacity chip. To perform measurements, one needs to supply heating currents to heat up the sample by about 1% of the bath temperature.

The heat capacity chip includes a micro-structured paramagnetic Ag:Er temperature sensor (see doi: 10.1007/10933596_4), which is read out by a dc-SQUID (Superconducting Quantum Interference Device) via a superconducting pickup loop. In this way, a relative temperature precision of 0.5uK can be reached. A third chip is placed between SQUID chip and heat capacity chip acting as a low pass filter and hence shielding the experiment from possible high-frequency noise stemming from the SQUID itself. The dc-SQUID will be driven in current mode to further reduce power dissipation. For this, a 2-stage SQUID setup will be employed.
The visitor Max Mustermann will be present during the experiment to help during the installation process and perform the actual measurements.

6. Requested Facility

'whatever best'