2020 HGF – OCPC – Programme

for the involvement of postdocs in bilateral collaboration projects

Title of the project:

Resonant X-ray magnetic study of novel compound EuPtAs

Helmholtz Centre, division/group:

DESY / FS / FS-PETRA-S

Project leader:

Dr. Sonia Francoual, Beamline Scientist in Charge, Beamline P09 at PETRA III at DESY

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https://photon-science.desy.de/facilities/petra_iii/beamlines/p09_resonant_scattering_and_diffraction/index_eng.html <insert the web address of the centre here>

Department/Group: (at the Helmholtz centre or Institute)

FS / FS-PETRA-S

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Description of the project (max. 1 page)**: Determining the magnetic structures of noncentrosymmetric EuPtAs in high magnetic fields**

Compounds containing rare-earth elements with partially filled f-electrons have been found to have a wealth of novel properties, including quantum criticality, unconventional superconductivity and multiple complex magnetically ordered ground states. Magnetic systems both lacking inversion symmetry and with significant spin-orbit coupling can exhibit the antisymmetric Dzyaloshinskii-Moriya (DM) exchange interaction between magnetic moments, in addition to the Ruderman–Kittel–Kasuya–Yosida (RKKY) interaction. The DM interaction can give rise to a number of complex non-collinear magnetic ground states, such as helical magnetic structures. Furthermore, in some systems such as MnSi, this has been shown to lead to a field-induced skyrmion phase with a topological spin texture. Subsequently, evidence for skyrmion phases has been found in several compounds with the B20-type structure of MnSi (space group P213), and moreover recent neutron diffraction measurements of another compound with the same space group, EuPtSi, was found to exhibit helical magnetic order, with a similar field-induced magnetic phase to established skyrmion systems.
EuPtAs which has a different noncentrosymmetric crystal structure (space group I41md) than EuPtSi presents a complex magnetic field – temperature phase diagram in relation with the DM exchange interaction inherent to that crystallographic space group. Here we wish to explore the magnetic

structure of EuPtAs and in particular the nature of the field-induced phases, due to the resemblance to the 'A'-phase in skyrmion systems. Due to the high neutron absorption cross section of Eu, X-ray Resonant Magnetic Scattering (XRMS) is best technique to solve the magnetic phase diagram puzzle in EuPtAs. As well the superior q resolution of X-rays will allow to look for subtle lock-in of the magnetic wavevector at the phase transitions.
XRMS at the Europium L_{III} and L_{II} absorption edges in high magnetic fields till 14 Tesla and at low temperatures is possible worldwide only at beamline P09 at PETRA III at DESY in Germany. Magnetic structure determinations from XRMS of complex magnetic systems there is further facilitated by the software crystallographic computing software MAGStREXS currently developed at beamline P09 at DESY and the possibility to manipulate the incident linear polarization of X-rays to carry out full linear polarization analysis and look for natural circular dichroic effects.
The successful applicant will be in charge to carry out XRMS measurements at beamline P09 at PETRA III on EuPtAs and subsequently determine the magnetic structure and magnetic space group in the different phases of EuPtAs in order to explain the macroscopic properties. He will be working in a team of 4 scientists, experts in crystallography, XRMS and XMCD at 3rd generation synchrotron sources but as well SCES and Kitaev materials.

Description of existing or sought Chinese collaboration partner institute (max. half page)**:**

The very unique sample environments at beamline P09 at PETRA III at DESY allow to probe antiferromagnetic, ferromagnetic, orbital and charge density wave long range ordering in correlated electron systems at the microscopic scale in high magnetic fields, at high pressure and low temperatures. This OCPC – Programme will allow to start a collaboration with Pr. Dr. Hui-Qiu Yuan who has been working on the emergent quantum phases and phenomena in strongly correlated electron systems since more than 20 years and is a well-known researcher in that research field. Pr. Dr. Hui-Qiu Yuan is leading a research center at Zhejiang University which synthetizes materials (inclusive EuPtAs) and probes their macroscopic and microscopic physical properties, including multiple measurements under extreme conditions of low temperature, high pressure and high magnetic field, ARPES, neutron scattering, muSR and so on. The collaboration with Prof. Dr. Huiqiu Yuan's group will allow us to investigate the strongly correlated systems using a complementary method available at DESY, which will be mutually benefited for the two institutions.

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Required qualification of the post-doc:

- PhD in Physics
- Experience with single-crystal diffraction, magnetic measurements using magnetic property measurement System (MPMS) and cryogenic systems (LHe, LN_2, He_3)
- Additional skills : GSAS
- Language requirement: English (Fluent)