ESRF	**Experiment title:** Relationship of superconducting transition temperature T_c and crystal-field ground state in $CeRh_x Ir_{1-x}In_5$	**Experiment number**: HE-3549
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Names and affiliations of applicants (* indicates experimentalists):

T. Willers*, F. Strigari*, A. Severing*
Institute of Physics II, University of Cologne, Zülpicher Straße 77, D-50937 Cologne, Germany

V. Sessi*, N.B. Brookes
European Synchrotron Radiation Facility (ESRF), B.P. 220, 38043 Grenoble Cedex, France

Z. Hu*, L. H. Tjeng
Max Planck Institute for Chemical Physics of Solids, Nöthnizer Straße 40, 01187 Dresden, Germany

Report:

The Ce 115 heavy fermion compounds $CeRhIn_5$, $CeIrIn_5$, and $CeCoIn_5$ possess a rich phase diagram revealing the interplay between the antiferromagnetic behavior of the cerium local *4f* moments, non Fermi liquid behavior and/or unconventional superconductivity (see Fig. 1 and Ref. 1). The possibility to continuously replace Rh by Co or Ir ions provides the opportunity to study the interplay of these different phenomena in a detailed manner. In the present experiment we wanted to address the question whether the crystal-field ground state anisotropy triggers the non-conventional d-wave superconductivity in Heavy fermion compounds. The availability of high quality single crystals of the substitution series $CeRh_xIr_{1-x}In_5$ allows to use polarization dependent x-ray absorption spectroscopy to determine the crystal-field ground state anisotropy. This spectroscopic method recently proved to be a useful tool to determine the ground state anisotropy with highest accuracy independent of any magnetic inter-site or on-site interactions.

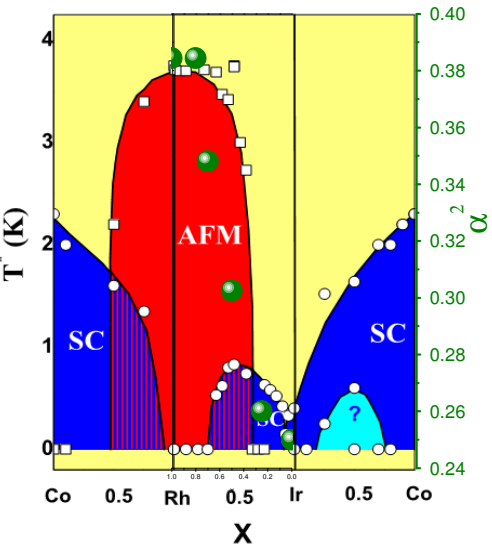

Fig. 1: Connected phase diagram of the Ce 115 family as taken from Ref. [1]. The green-white triangles represent the mixing paramter α^2 as determined in this work.

In tetragonal *4f* systems the sixfold degenerate Hund's rule ground state of Ce^{3+} (J=5/2) is split into three Kramer's doublets under the influence of the crystal field and the eigenfunctions can be represented in the basis of $|J_z>$ when the fourfold symmetric tetragonal [001] axis is chosen as quantization axis. There are two Γ_7 doublets $\Gamma^1_7 = \alpha|\pm 5/2> + \sqrt{(1-\alpha^2)}|\mp 3/2>$ and $\Gamma^2_7 = \alpha|\pm 5/2> - \sqrt{(1-\alpha^2)}|\mp 3/2>$, and one Γ_6 which is a

pure |±1/2> doublet. For the Γ_7 doublets the mixing parameter α solely describes the anisotropy of these states.

The high-quality single crystals of $CeRh_xIr_{1-x}In_5$ were grown with the flux-growth method and their quality and orientation were confirmed by Laue x-ray diffraction. We recorded all spectra using the total electron yield method in a chamber with a pressure of 5 x 10^{-10} mbar at the ID08 undulator beam line of the ESRF. The total electron yield signal was normalized to the incoming photon flux I_0 as measured on an Au-mesh before the entrance of the experimental chamber. Clean sample surfaces were obtained by cleaving the samples *in situ* at 4 K. The entrance and exit slit were both set to 30μm. The undulator together with a normal incident measurement geometry allow for a change of polarization without changing the probed spot on the sample surface which guarantees a reliable comparison of the spectral line shapes.

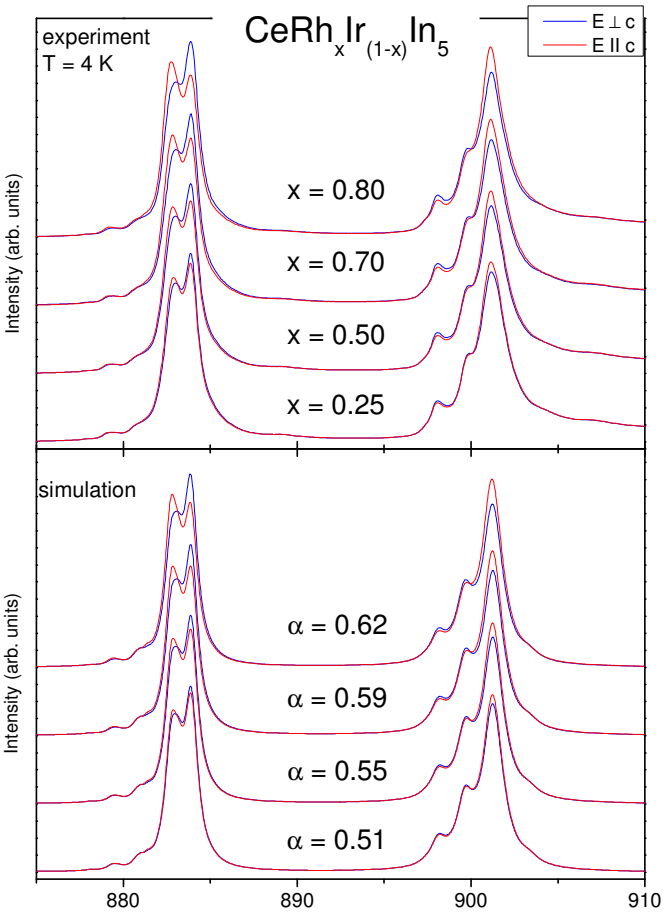

Fig. 2: Linear polarized XAS spectra of $CeRh_xIr_{1-x}In_5$ (top panel) and corresponding sumulations(bottom panel).

In the top panel of Fig. 2 the polarization dependent XAS spectra of the substitution series $CeRh_xIr_{1-x}In_5$ taken for x = 0.25, 0.5, 0.7, and 0.8 are shown. All spectra were taken at 4 K in order to guarantee that only the ground state is thermally populated, i.e. probed. The observed linear dichroism continuously increases from x=0.25 to 0.8. The bottom panel shows simulations reproducing the experimental data. The simulations are based on the full multiplet treatment as described elsewhere [2] and the agreement between experiment and simulation is excellent. We find that the mixing parameter α increases from α =0.51 for x = 0.25 to α = 0.55, 0.59, and 0.62 for x=0.50, 0.70 and 0.80, respectively. In a previous work [2] we determined the mixing parameters for the pure compounds to be α =0.50 and 0.62 for x=0.0 and 1.0. In Fig. 1 the α^2 values for all six different substitutions are plotted into the phase diagram as white-green balls. We have plotted α^2 and not α since the anisotropy goes linearly with α^2. From a first glance analysis we find a nice correlation between Neel temperature and ground state wave function (crystal-field anisotropy): α decreases smoothly as T_N decreases and is more or less constant for $x \leq 0.25$, i.e. for the non ordering compositions. In contrast, a direct relationship between α and T_c remains speculative.

References:

[1] J. L. Sarrao and J.D. Thompson, J. Phys. Soc. Japan 76 (2007), 051013

[2] T. Willers *et al.*, Phys. Rev. B 81, 195114

[3] T. Willers, M. Koza, E.D. Bauer, A. Severing (unpublished)