ESRF	**Experiment title:** High-Purity Polarimetry for X-ray Quantum Optics	**Experiment number**: HC 831
Beamline: ID18	**Date of experiment**: from: 4.6.2013 to: 11.6.2013	**Date of report**: 3.3.2014
Shifts: 18	**Local contact(s)**: Rudolf Rüffer	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Daniel Schumacher*, Kai Sven Schulze*, Ralf Röhlsberger*, Robert Lötzsch*, Kai Schlage, Hans-Christian Wille, Ingo Uschmann

Report:

The original aim of this proposal was to measure the impact of spontaneously generated coherences on nuclear resonance energy spectra of x-ray cavities that contain ensembles of Mössbauer nuclei. It appeared, however, that we could do this experiment already at PETRA III before this experiment was scheduled at the ESRF.

Instead, we decided to devote this beamtime to another very interesting quantum optical phenomenon, namely the appearance of (nuclear) resonant Bragg polaritons in the vicinity of a pure nuclear Bragg reflection from an isotopic $^{57}Fe/^{56}Fe$ multilayer.

Peak splitting close to the Bragg angle results from vacuum Rabi splitting due to collective strong coupling in a photonic nanostructure (the isotopic multilayer). If this interpretation can be confirmed, this would be the first direct observation of an analogue of vacuum Rabi splitting in the x-ray regime. Similar observations have been made in microcavities, semiconductor superlattices, and plasmonic slit arrays.

Experimental data are shown in Fig. 1. Red lines are theoretical simulations that were performed during the beamtime. Spectroscopic signature of strong coupling is a mode structure that exhibits level anticrossing, as shown in Fig. 2, evidenced by plotting the split peak positions (here: outer left peak of the spectrum) as function of incidence angle (or momentum transfer).

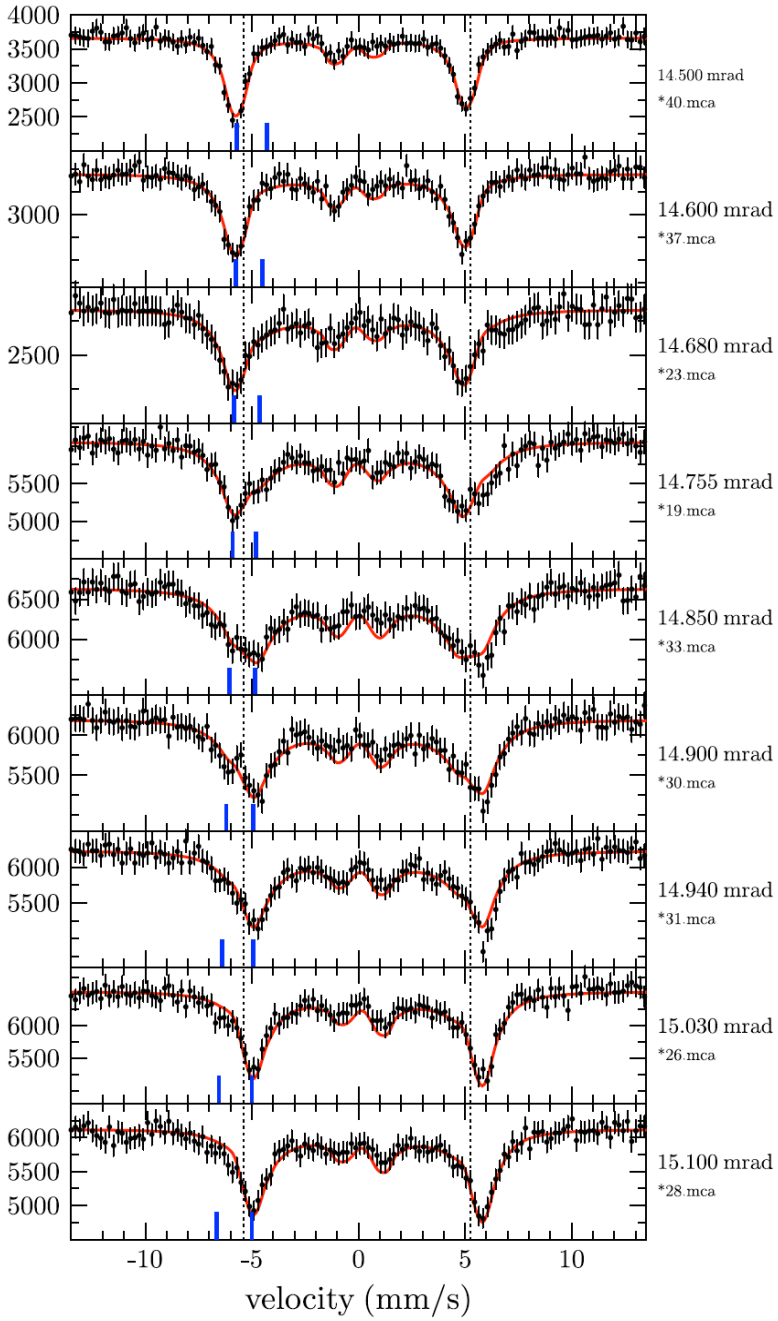

Fig. 1: Measured energy spectra of the 57Fe/56Fe multilayer around the pure nuclear Bragg peak at 14.85 mrad, indicating a pronunced peak splitting of the outer resonance lines at the exact Bragg angle.

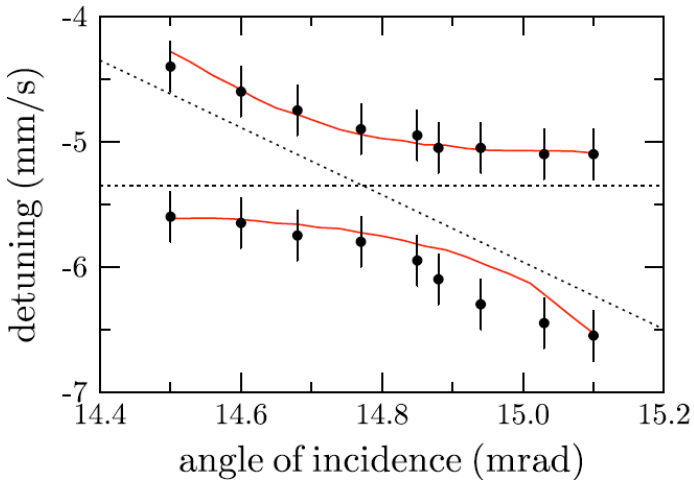

Fig. 2. : Peak splitting (detuning) as function of incidence angle around the pure nuclear Bragg peak, indicatiing an avoided crossing as it is typical for Bragg polaritons