ESRF	**Experiment title:** Observation of critical order fluctuation in metal-hydrogen systems by coherent x-rays	**Experiment number:** HS-353
Beamline: ID10	**Date of experiment:** from: 02-Dec-97 to: 09-Dec-97	**Date of report:**
Shifts: 18	**Local contact(s):** Dr. Gerhard Gruebel	*Received at ESRF:* 2 8 AOUT 1998

Names and affiliations of applicants (all are experirnentalists):

S. Schmid, T. Edelmann, J. Peisl, T. H. Metzger, Ludwig-Maximilians-Universitat München
G. Gruebel, ESRF

Report:

The aim of this experiment was the observation of critical fluctuations of a order-disorder phase transition in a metal-hydrogen system by coherent x-rays. Some metals like niobium or vanadium dissolve large amounts of hydrogen (H), up to concentrations of one H atom per metal atom. Hydrogen is located in the metal lattice on interstitial sites and expands the lattice. The long ranged elastic displacement field in the metal lattice causes an indirect elastic interaction between the hydrogen atoms. Hydrogen in these metals behaves in many respects like a lattice gas showing phase transitions depending on hydrogen concentration c and temperature T. Analogous to the solid phase in a lattice gas there are ordered hydrogen phases at lower temperatures in many metal hydrogen systems. In the case of V_2H there are two ordered phases. Hydrogen in the low temperature phase (β_1) modulates the host lattice leading to a superstructure Bragg reflection at (h/2 h/2 0). With increasing temperature a continuous phase transition occurs to the high temperature β_2 phase. In the β_2 phase there is no equivalent modulation of the host lattice, therefore the superstructure reflections disappear associated by the appearance of critical diffuse scattering. The observation of the critical scattering near the critical temperature T_c with coherent x-rays offers the possibility to study the dynamics of the critical order-disorder fluctuations. The disappearance of the superstructure reflection (1/2 1/2 0) of the low temperature phase with increasing temperature was observed using coherent x-rays from the undulator source (Fig. 1).

A two dimensional x-ray CCD detector was used to detect speckle patterns caused by the domain , structure of the V_2H crystal. To obtain sufficient time resolution time series were taken at every temperature by measuring 1000 patterns, each of one second duration. Although the jump rate of hydrogen is very high, the dynamics of order-disorder fluctuations should slow down drastically near the critical temperature T,. Therefore below T_c an uncorrelated signal dominated by static domains is expected (static speckle pattern) (Fig. 2) whereas near T_c dynamic patterns are expected with a characteristic temperature dependent fluctuation correlation time. By choosing temperature steps of 0.2 degrees close to the phase transition we searched for a temperature with a fluctuation correlation time falling in the accessible range of 2 to 1000 seconds.

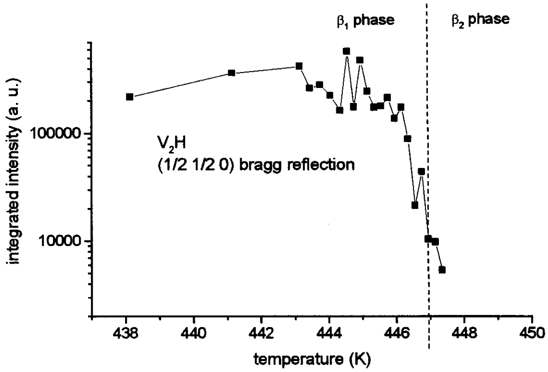

Figure 1: Intensity integrated over static speckle pattern from the (l/2 l/2 0) superstructure bragg reflection.

Figure 1 shows the disappearing of the superstructure Bragg reflection due to the β_1-β_2 phase transition. Every point represents the summation over 1000 single pictures (1000 seconds) from the CCD detector. Figure 2 shows one of these static speckle patterns (below T_c).

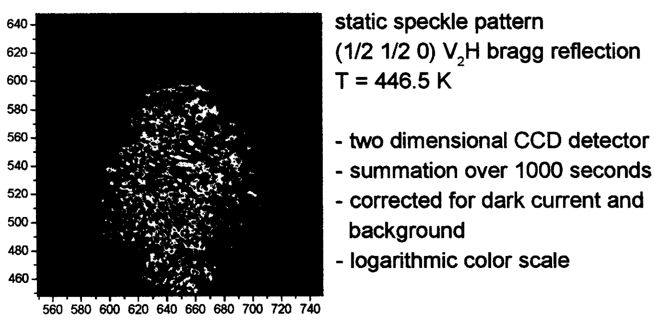

Figure 2: Static speckle pattern.

In order to detect fluctuations a fourier transformation of the intensity of one chosen speckle over a time serie was calculated. Due to this every pattern had to be corrected for dark current and background intensity. This was made over the whole temperature range with different single speckles. No significant periodical structure could be found.