Neutron Scattering Studies of Short-Range Order and Atomic Displacements in a Null-Matrix $^{62}Ni_{0.52}\ Pt_{0.48}$ Crystal

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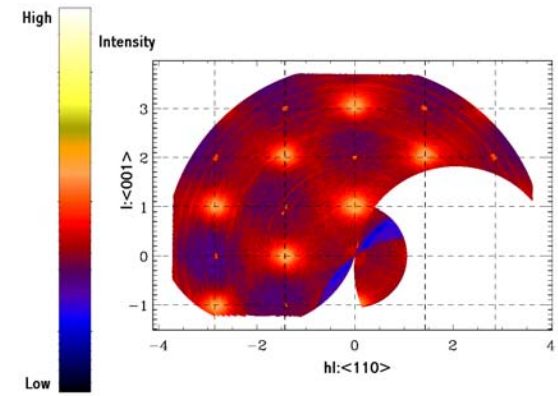
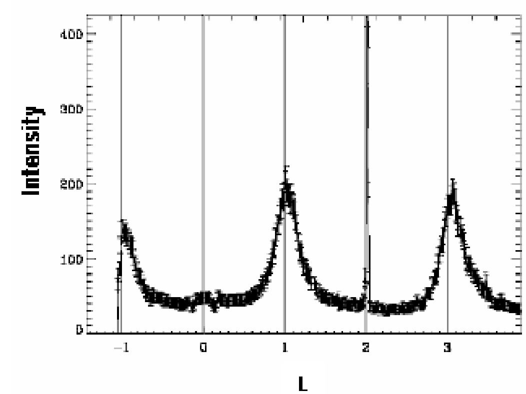
Diffraction from disordered alloys is a unique technique to analyze the structure and dynamics of a host of materials to compare with electronic structure calculations. The total diffuse intensity from a disordered alloy is given below, where the Bragg scattering is not included, although it is almost always present

$$I_{diff} = I_{TDS} + I_{SE} + I_{Huang} + I_{SRO}$$

For a binary A-B alloy the I_{Bragg}, I_{TDS} (thermal scattering) and I_{HDS} (static displacement scattering) are all proportional to $(x_A b_A + x_B b_B)^2$. I_{SRO} (short-range order scattering) and I_{SE} (size-effect due to the cross term between concentration fluctuations and displacements) are proportional to $(x_A b_A - x_B b_B)^2$, where x_A and x_B are the concentrations and b_A and b_B are the neutron scattering lengths. This null-matrix alloy consists of an isotopic substitution of ^{62}Ni which has a negative scattering length and we thus have $x_A b_A + x_B b_B = 0$, where the normal Bragg, TDS and HDS scattering vanish and we can see the pure contribution of the SE and SRO, which permits a much better evaluation of the physical parameters relevant to theory.



NiPt null-matrix (1 -1 1) plane. The tiny dots are the Bragg contribution and can be ignored.



NiPt null-matrix (00L) line scan. The contribution of the Bragg scattering is negligible (note L=2), while the size effect shows the expected, albeit small, asymmetry which increases with L.

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The nature of neutron scattering differs from x-ray scattering mainly because the scattering lengths do not have an angular dependence (the x-ray form factor falls off with $\sin(\theta)/\lambda$ as x-rays are scattered by the electrons). The nuclear scattering length, b, is different for different isotopes of the same element and can even show a phase shift of 90°(i.e. can be negative). With x-rays it is always positive.

Our null-matrix study takes advantage of this property of neutrons and permits a measurement of purely elastic scattering using the elastic channels of the NIST chopper spectrometer, (see description on the right).

The collaborators in this work are
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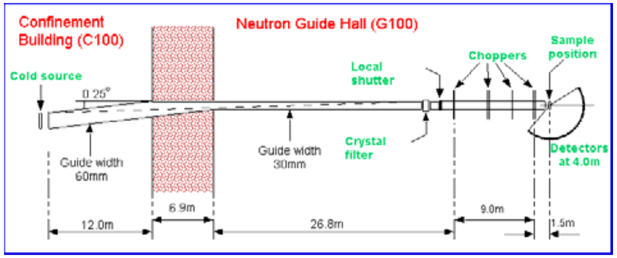
The excellent crystal was grown by J. Major at MPI für Metallforschung-Stuttgart with the collaboration of H. Dosch and H. Reichert.



The area scans were done on the NIST Disk Chopper Spectrometer (DCS). This work utilized facilities supported in part by the National Science Foundation under Agreement No. DMR-0086210.

The DCS uses a set of seven chopper disks and a partitioned guide to produce pulses of neutrons of a single wavelength at the sample position. Having the initial velocity of the neutrons, the distance between the sample and the detectors, and the time of flight of a neutron, we can calculate the energy transferred of the scattered neutron. In this fashion we collect at the same time both elastic and inelastic data. The latter can be used with a normal Ni-Pt crystal to obtain the phonon dispersion curves. In a null-matrix this scattering is also absent.