ESRF	Experiment title: Fermi Surface Determination of a Decagonal Quaisicrystal via Compton Scattering		Experiment number: HE-571
Beamline: ID15B	Date of experiment:from:14JUN99to:22JUN99		Date of report: 19July99
Shifts: 21	Local contact(s) : Dr. Thomas Buslaps		Received at ESRF:
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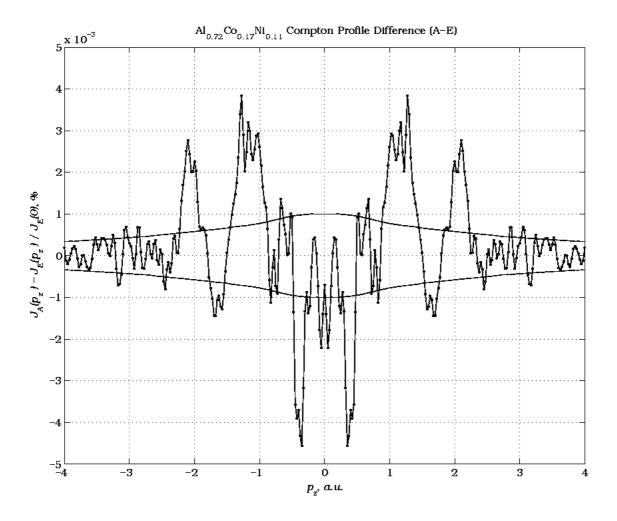
REPORT: Quasicrystals are solids that are neither periodically ordered, like ordinary crystals, nor disordered or amorphous. This form of matter has a well-defined, discrete point group symmetry, like crystals, but one, which is explicitly incompatible with periodic translational order. Instead, quasicrystals possess a quasiperiodic long-range order. Decagonal quasicrystals share structural properties with solids exhibiting both periodic and quasiperiodic types of long-range order. They are periodic along the decagonal axis and quasiperiodic in the plane perpendicular to it, thus exhibiting an unconventional structural anisotropy. For decagonal quasicrystals in the Al-Cu-Co and Al-Ni-Co alloy systems (five-dimensional space group P10₅/mmc) strong anisotropies of electrical [1,2] and thermal transport [3,4] as well as the optical conductivity [4,5] have been established experimentally. Theoretical calculations of the electronic structure of decagonal quasicrystals meet difficulties, mainly because the structure is non-periodic in the plane normal to the 10-fold symmetry axis. However, some of the electronic properties of decagonal quasicrystals can be explained assuming the existence in these phases of a many-pocketed Fermi surface as, for

example, in semimetals. This suggests that it would be desirable to undertake experimental investigations of the Fermi surface in decagonal quasicrystals. Previous attempts using the de Haas--van Alphen effect in these materials were unsuccessful, most likely because the mean free path of charge carriers in these materials is rather short.

In order to gain a better understanding of the electronic structure of decagonal phases, we employed Compton scattering, a technique that is not sensitive to the mean free path of charge carriers. Here we report the results of measurements of the projection of the electron momentum distribution (EMD) along several crystallographic directions of a single-grain Al-Ni-Co decagonal quasicrystal. The flux-grown single-grain quasicrystal was cut and polished into a rectangular parallelepiped with dimensions x = 7 mm, y = 1.5 mm and z = 1.5 mm, with x and y parallel to the 2-fold axes and z parallel to the decagonal axis. Radial scans showed a mosaic spread of only 0.14 degrees in the 2-fold direction, indicating a high quality sample. Using quantitative X-ray microanalysis, the composition was found to be 72 at.% Al, 17 at.% Co and 11 at.% Ni.

Compton profiles were measured in air with the scattering vector parallel to the 2-fold, 10-fold and four other crystallographic directions. In our experiment, the incident X-ray beam was 4.6 mm in height and 0.2 mm in width which allowed us to collect the Compton data with excellent statistics of better than 0.1 % at the Compton peak which lead to statistics in the anisotropy differences of about 0.1%. We applied corrections for air absorption and sample self-absorption, normalization to the incident beam monitor, efficiency of the analyzer and slit effects. The contribution from the core electrons was calculated using theoretical profiles corrected for the impulse approximation. In order to obtain the Compton profiles, we fit the tails of the Compton peak to the core profiles. Then, the spectrum was converted to the momentum scale, normalized to the electron number and symmetrized. Differences in the Compton profiles along different crystallographic directions were computed. In the figure below, we show the difference between the Compton profiles taken along the 2-fold and the 10-fold directions. The solid lines indicate the statistical uncertainty of our measurements. As a first observation, we note distinct features, much broader than the experimental resolution, indicative of strongly anisotropic Fermi surface, and we believe is the first observation of this phenomena.

Further refinement of our data will include corrections for multiple scattering. The complete data analysis will include modeling of the electronic structure of decagonal Al-Ni-Co and a detailed comparison between theoretically calculated and experimentally determined Compton profiles. We expect that our experimental results and analysis will lead to better understanding of the electronic structure of decagonal phases.



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