Preliminary resistivity results on U_2Ni_2Sn single crystals

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U_2Ni_2Sn is a member of a large family of intermetallic compounds with the tetragonal Mo_2FeB_2 crystal structure, which has been studied intensively over the past years [1-3]. It orders antiferromagnetically at 25 K with a propagation vector $q = (0, 0, 1/2)$. Magnetization, magneto-acoustic, and neutron-diffraction experiments on a single crystal provide evidence that the uranium moments align parallel to the *c*-axis with the anisotropy energy of ≈170 K, indicating that U_2Ni_2Sn can be classified as an Ising system. This behavior is rather exceptional, majority of the isostructural uranium ternaries have U moments confined into the basal plane.
Last results [1] are actually at variance with previous studies on polycrystals, which indicated different magnetic structure, and which were incompatible with the 5*f*-5*f* two-ion anisotropy model dominant in most of U band systems. High-field magnetization studies [1] exhibit a weak linear response for fields along the basal plane up to the highest field applied (60 T), while the *c*-axis magnetization curve exhibits three metamagnetic transitions at approximately 30, 39 and 50 T.

Few single crystals of U_2Ni_2Sn were grown by the Czochralski method from a stoichiometric mixture of the pure elements (99.9% U, 99.99% Ni and 99.9999% Sn) in a tri-arc furnace with a water-cooled copper crucible under protective argon atmosphere. A tungsten rod was used as a seed. The pulling speed was 10 mm/h. We cut two different single crystal pieces for resistivity measurements with orientation of [001] and [110], respectively. The small size of crystals was chosen to be compatible with high-pressure study envisaged.
The four-point technique, as shown in Fig. 1, was used to measure the resistivity. 25 µm Au wire was used as leads for the measurement.

Although the primary goal is the high-pressure study (as U_2Ni_2Sn is an itinerant antiferromagnet, we expect fast suppression of magnetic order with pressure), already the ambient pressure data (see below) yield an interesting insight.

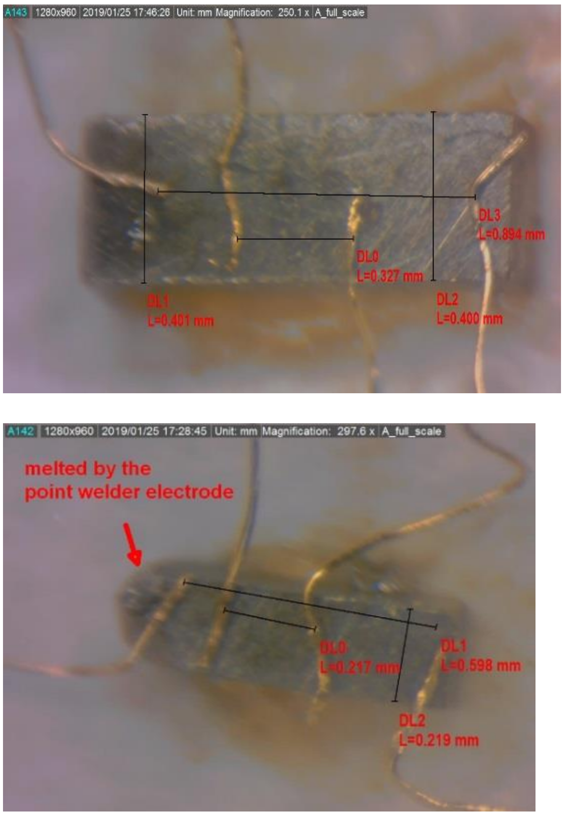

Figure 1. Single crystals of U_2Ni_2Sn mounted for the resistivity measurement in the [001] (up) and [110] (down) direction.

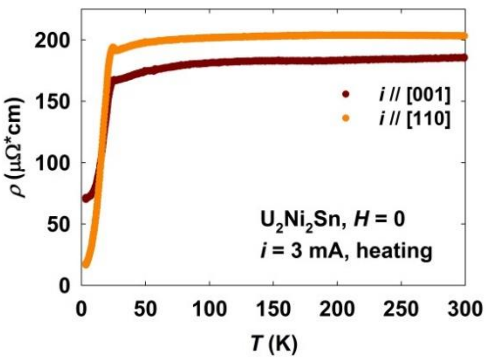

Figure 2a. The temperature dependence of resistivity of U_2Ni_2Sn single crystal with i // [110] and i // [110] (left).

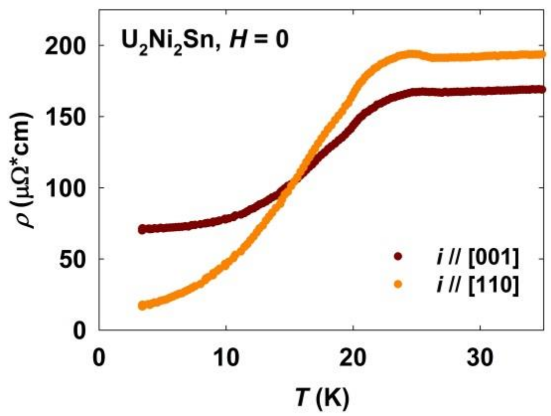

Figure 2b. The temperature dependence of resistivity of U_2Ni_2Sn single crystal with i // [110] and i // [110] (left) The low-temperature detail.

The first finding is that single crystal resistivity has better RRR value, reaching 10 for i // [110] and 3 for the [001] direction. The polycrystal value is about 3 [2]. None of the two directions exhibits the negative resistivity slope, d□/dT <0, found for the polycrystal, and Δ (T) shows merely a saturation. The magnetic propagation vector implies an influence of magnetic superzone gapping for [001], which can explain much higher residual resistivity in this direction. There is AF coupling between the U moments within the same basal-plane sheet, but it all happens within one unit cell, accommodating 4 U atoms.

Further differences are revealed by a numerical analysis. Fitting for i // [110] indicates the quadratic dependence, compatible with the high uniaxial anisotropy, not permitting a population of magnons with energy lower than the anisotropy gap. On the other hand, i // [001] exhibits an additional gap excitation term, $\rho = \rho_0 + AT^2 + C * exp\left(-\frac{\Delta}{T}\right)$ with Δ = 40-60 K, i.e. much smaller than the anisotropy gap 170K. Such exchange gap has to be identified as a spin gap, suggesting an easy spin flipping along c.

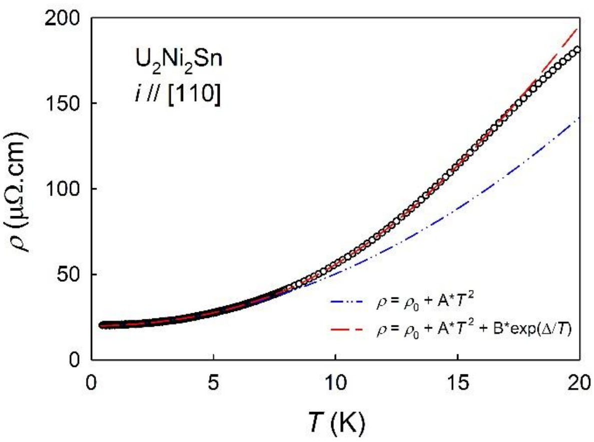

Figure 3. The temperature dependence of resistivity of U_2Ni_2Sn single crystal with i // [110] and i // [110] fitting.

The temperature dependence on pressure and field of resistivity of U_2Ni_2Sn single crystal with i // [110] and i // [110], are shown in figers 4 and 5. on boths transition temperatures goes down on higher fields or pressure.

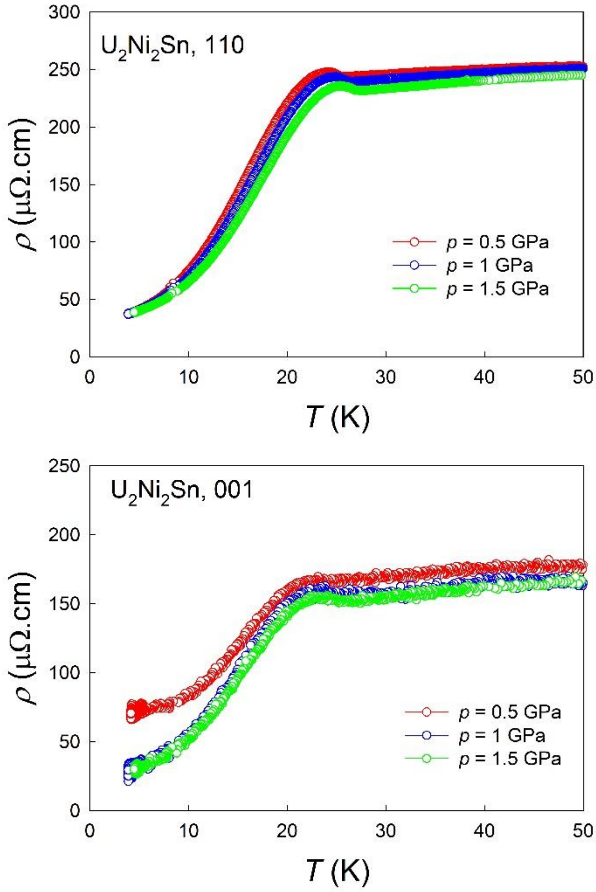

Figure 4. The temperature and pressure dependence of resistivity of U_2Ni_2Sn single crystal with i // [110] and i // [110] .

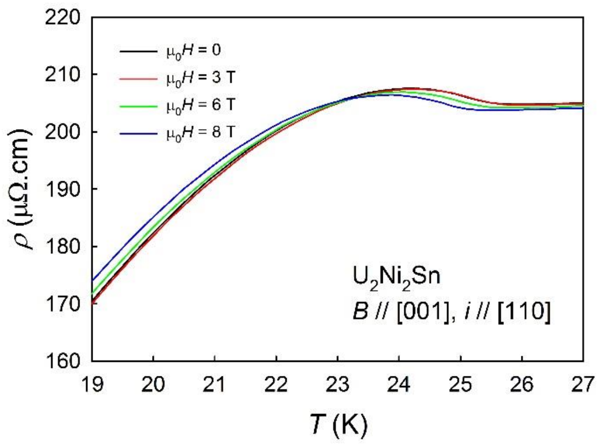

Figure 5. The temperature dependence of resistivity of U_2Ni_2Sn single crystal with i // [110] and B // [001] .

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