# Magnon-drag thermopower in antiferromagnets versus ferromagnets

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## S1 Crystal Structure of $Mn_{1-x}Cr_xSb$ from XRD Analysis

The similarity in the XRD patterns of $Mn_{1-x}Cr_xSb$ samples evidences the similarity of the crystal structures with gradually varied lattice parameters. All $Mn_{1-x}Cr_xSb$ samples have NiAs hexagonal crystal structure, where lattice parameter *a* and *c* as well as *c/a* ratio vary with x. Previous study [19,21] showed that lattice parameter *a* has insignificant variation with x, while *c* decreases with x. This variation of the unit cell structure is also observed in the shift of XRD peaks of $Mn_{1-x}Cr_xSb$ samples. Table 1 summarizes the XRD results including the position of the first XRD peak, *c* and *c/a* ratio along with the previous works [19,21].

*Table 1: Lattice parameters of $Mn_{1-x}Cr_xSb$ determined from XRD*

| Sample | 1st peak position (°) | *c* (Å) | *c/a* | c (Å) from [19]/[21] | *c/a* from [19]/[21] |
|---|---|---|---|---|---|
| MnSb | 29.42 | 5.773 | 1.399 | 5.789/5.755 | 1.402/1.38 |
| $Mn_{0.8}Cr_{0.2}Sb$ | 29.50 | 5.754 | 1.396 | --/5.784 | --/1.403 |
| $Mn_{0.5}Cr_{0.5}Sb$ | 29.80 | 5.693 | 1.393 | 5.697/-- | 1.391/-- |
| $Mn_{0.3}Cr_{0.7}Sb$ | 29.85 | 5.620 | 1.372 | 5.625/-- | 1.371/-- |
| $Mn_{0.2}Cr_{0.8}Sb$ | 29.86 | 5.576 | 1.358 | 5.584/5.585 | 1.359/1.358 |
| CrSb | 30.10 | 5.45 | 1.328 | 5.467/5.464 | 1.327/1.326 |

## S2 Spin Characteristics of $Mn_{1-x}Cr_xSb$

The spin number along with the magnetic transition temperatures of $Mn_{1-x}Cr_xSb$ samples are determined from magnetic susceptibility measurements. Figure 2, 3 and 4 along with table 2 summarize the results of the measurements. The following table compares the magnetic data from this work with the previous work [19], which shows a good agreement.

| Materials | $T_c$ (K) [This work] | $T_N$ (K) [This work] | $T_c / T_N$ [19] | *S* [This work] | S [19] |
|---|---|---|---|---|---|
| MnSb | 600 | -- | 600 | 1.64 | 1.70 |
| $Mn_{0.8}Cr_{0.2}Sb$ | 480 | -- | -- | 1.59 | -- |
| $Mn_{0.5}Cr_{0.5}Sb$ | 390 | -- | 390 | 1.42 | 1.45 |
| $Mn_{0.3}Cr_{0.7}Sb$ | 250 | ~520 | 255/500 | 1.45 | 1.55 |
| $Mn_{0.2}Cr_{0.8}Sb$ | 150 | ~600 | 130/590 | 1.40 | 1.60 |
| CrSb | -- | ~710 | 705 | 1.87 | 1.90 |

To obtain further understanding of the spin characteristics, previously reported data from neutron measurements [19-21] are compared with the data from this work. According to the above table, some difference is observed in the spin numbers. The spin numbers in this work are calculated from the linear fit of the inverse magnetic susceptibility in the paramagnetic domain. Some variation can be due to the calculation error. One important observation is that S for $Mn_{1-x}Cr_xSb$

($0 < x < 1$) is less than those of both MnSb and CrSb. As shown in figures 4 and 5, $Mn_{1-x}Cr_xSb$ samples have canted spin orders, in agreement with [19-21]. Due to the mixture of FM and AFM interactions, the effective magnetic moment of $Mn_{1-x}Cr_xSb$ depends on the canting angles. The angles are reported in [21] for $Mn_{1-x}Cr_xSb$.

In addition to the canted phase, zero-field interaction of 3d-elements, crystal field, and defects also play critical roles in the spin numbers. Therefore, it is more convenient to study the spin characteristics from the atomic magnetic moment rather than the spin number, as the atomic moment can be determined from neutron diffraction patterns. Moreover, the atomic magnetic moment has a proportional relation with the spin number. From the neutron diffraction reported in [19], it is observed that for $0 \leq x \leq 0.75$, the average atomic magnetic moment reduces with x, and then the moment increases within $0.75 < x \leq 1$ range. The calculated spin numbers in this work also show a similar trend.