

Uniaxial stress tuning of the anomalous Hall effect in Mn₃Ge

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Tunable electronic properties in magnetic materials lead to novel physical phenomena that have the potential to be exploited in the design of new spintronic devices. Here, we report the effect of uniaxial stress on the anomalous Hall effect (AHE) in the hexagonal frustrated antiferromagnetic Heusler compound Mn₃Ge. Our x-ray diffraction results show that the c/a ratio varies linearly with strain when stress is applied along the a axis, as well as a significantly higher Young's modulus along the c direction. The linear behavior of the c/a ratio under uniaxial stress mirrors that seen under hydrostatic pressure up to 1.8 GPa, but results in a characteristically different behavior of the AHE. Stress applied along the a axis induces a distortion in the ab plane, smoothing the abrupt jump in the AHE signal at zero magnetic field. In contrast, stress applied along the c axis has little effect, presumably due to the higher Young's modulus. We argue that this is due to pronounced changes in magnetic order.

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I. INTRODUCTION

Spintronics, which exploits the spin degree of freedom in electronic devices, has traditionally focused on ferromagnetic (FM) materials [1–11]. However, antiferromagnetic (AFM) materials aim to replace ferromagnets in spintronic devices due to their resistance to perturbations, lack of stray fields, and suitability for high-density memory integration [12–16]. In addition, they exhibit ultrafast dynamics and significant magneto-transport effects, making them essential for applications such as nonvolatile memory and magnetic field probes [17].

The Mn₃X family ($X = \text{Ge, Sn, Ga, Ir, Rh, and Pt}$) hosts several candidates for such applications due to their antiferromagnetic order and chiral nature in transport phenomena [1–6]. Among these, Mn₃Ge has a well-established history of exhibiting nontrivial electronic properties, driven by its chiral magnetic field generated by canted spins in the kagome lattice [8]. Hydrostatic pressure applied to Mn₃Ge can progressively tune the anomalous Hall effect (AHE) signal, even leading

to a signal reversion above a critical pressure [18]. Recently, uniaxial stress has proven to be an effective tool for tuning the electronic and magnetic properties of kagome materials [19–22]. These advances make uniaxial stress a promising method for precisely controlling the chiral properties and related effects in Mn₃Ge for use in novel spintronic devices.

Mn₃Ge is a Heusler compound that can crystallize in hexagonal ($P6_3/mmc$) and tetragonal ($I4/mmm$) structures [23]. This study focuses on the hexagonal structure, which exhibits triangular AFM ordering with T_N ranging from 365 K to 400 K [24]. In this structure, the unit cell of Mn₃Ge consists of two layers of Mn stacked along the c axis. Within each layer, the Mn atoms form a kagome lattice, with Ge positioned at the center of each hexagon.

Recent theoretical and experimental studies have emphasized the potential of strain and stress to modify the electronic and magnetic properties of Mn₃Ge. One theoretical work predicted that both in-plane and out-of-plane stress can effectively tune the Hall effect in hexagonal Mn₃Ge by introducing an easy-axis anisotropy within the kagome lattice, which leads to a net strain-dependent moment [25]. Another proposed that chiral orders form below 200 K and that magnetic moments resist directional changes under rotating magnetic fields in the absence of crystalline defects [26]. Experimentally, strain of $\approx 0.1\%$ was shown to tune the AHE in Mn₃Sn [27], and epitaxial strain modulated the AHE in both Mn₃Sn [28] and Mn₃Ga [29].

In the present study, we investigate the effects of in-plane and out-of-plane uniaxial stress on the AHE in Mn₃Ge, taking advantage of the strain-sensitive chiral properties of the

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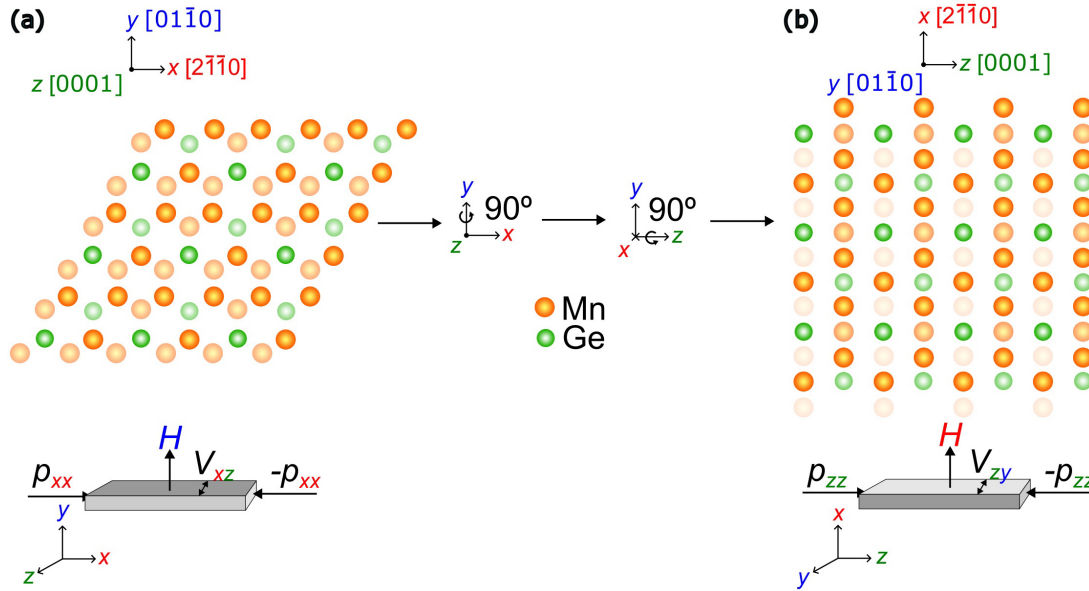


FIG. 1. Real-space structures of Mn₃Ge illustrating two experiments with stress applied along different directions. (a) Stress was applied along the $[2\bar{1}\bar{1}0]$ direction, i.e., along $[10\bar{1}0]$ (x direction) in real space. The magnetic field was applied perpendicular to the x axis, in the y direction, aligned with the $[01\bar{1}0]$ direction. Finally, the Hall voltage (V_{xz}) was measured along the $[0001]$ direction, referred to as the z axis in real space. The second configuration is obtained by performing two successive counterclockwise 90° rotations on the real lattice. First, a rotation around the y axis, followed by a second rotation around the z axis. (b) Stress was then applied along the z axis while the magnetic field was directed along the x axis. Hall voltage (V_{zy}) was measured along the y axis.

material. By exploring these effects, we aim to extend the tunability of Mn₃Ge for spintronic applications.

II. METHODS

High-quality hexagonal Mn₃Ge single crystals were grown using the Bridgman-Stockbarger technique [8]. Energy-dispersive x-ray spectroscopy (EDX) measurements revealed a sample homogeneity with atomic percentages of Ge between 23.88-25.66%. Single-crystal x-ray diffraction (XRD) was performed at the EMA beamline (Sirius) with a 25.514 keV beam focused to a $100 \times 100 \mu\text{m}^2$ spot. A Razorbill CS200T strain cell on a 6-axes diffractometer applied uniaxial stress and selected reflections were tracked with a Pilatus 300 K CCD detector [32]. Strain values were determined from the peak shifts with a zero-strain reference corresponding to no voltage applied on the piezo stacks. Electrical transport was measured using a five-point geometry with an LR-700 resistance bridge. Temperature and magnetic field were controlled with a Quantum Design PPMS. The transverse resistivity was antisymmetrized to isolate the Hall contribution. Stress was applied using a Razorbill CS100 strain cell, and length change was monitored using the integrated capacitive sensor and an Andeen-Hagerling AH-2500A capacitance bridge. Two bar-shaped samples were investigated in the electrical transport experiments (see Fig. 1 for details). Both samples had the same thickness $t = 170 \mu\text{m}$ and width $w = 250 \mu\text{m}$. The free distances between the claws of the strain cell were $350 \mu\text{m}$ for sample 1 and $890 \mu\text{m}$ for sample 2. For the Hall experiments, the voltage contacts were positioned on the homogeneously strained part of the sample. Following Hicks *et al.* [33], we could estimate a strain inhomogeneity across the sample thickness of less than 1%.

III. RESULTS

We have studied the effect of uniaxial strain on the crystal structure and the AHE in Mn₃Ge for two characteristically different configurations, applying stress within and perpendicular to the kagome plane. In both cases, the magnetic field was applied parallel to the kagome plane (see Fig. 1). In sample 1, the stress was applied in the basal plane parallel to the current, along the $[2\bar{1}\bar{1}0]$ direction. This direction corresponds to the a axis in real space and is defined as the x direction in the electrical transport experiments. The magnetic field was applied perpendicular to the stress and current directions along $[01\bar{1}0]$, defined here as the y direction (b^* axis). In sample 2, the stress and current are applied perpendicular to the basal plane along the $[0001]$ direction (c axis), defined here as the z direction. In this case, the magnetic field is applied along the x direction. We observe a clear difference in the behavior of the AHE in these two different configurations. Before discussing the AHE data obtained under uniaxial strain in detail, we will first examine the structural changes with applied stress.

XRD experiments under uniaxial stress applied along the a direction allow us to compare our AHE results with previous results under hydrostatic pressure based on the crystal structure [18]. The strain induced in the sample by the stress applied along the a direction ϵ_a was determined by measuring the shifts of the diffraction peaks corresponding to the $(12\bar{6}60)$, $(01\bar{2}120)$, and (0008) reflections. These reflections correspond to crystallographic directions collinear to the x , y , and z directions, respectively, used in the electrical transport experiments (see Fig. 1) and were accessible due to the experimental geometry at the beamline. A maximum compressive strain of about -0.17% was achieved with no structural phase transition observed.

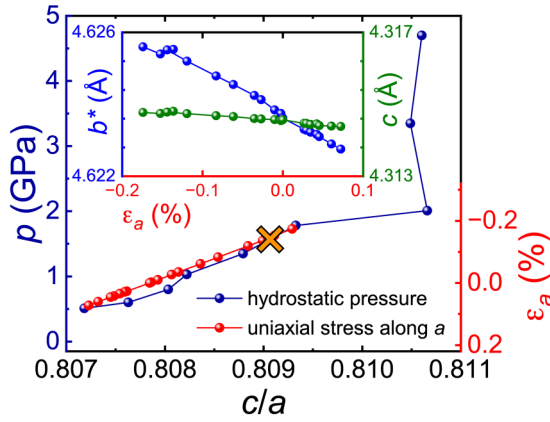


FIG. 2. XRD results under applied stress along the a direction are compared with hydrostatic pressure data extracted from [34], both at 300 K. The right axis of the plot (red spheres) shows the relative strain along a , ε_a , as a function of the lattice parameter ratio c/a , where zero strain corresponds to the nominal experimental value. The left axis (blue spheres) represents the applied hydrostatic pressure as a function of c/a . The “X” marks the point at which the AHE is suppressed under hydrostatic pressure. The inset shows the variation of the interplanar planes d_{0110} , corresponding to b^* , and d_{0001} , corresponding to the lattice parameter c , as a function of strain under stress applied along the a direction. The step size is the same for the left and right axes.

The inset of Fig. 2 shows the variation of b^* and c , corresponding to the interplanar distances d_{0110} and d_{0001} , respectively, as a function of ε_a . The data are consistent with the significant difference in elastic moduli, with the c axis having a larger Young’s modulus [35]. While stress in the a direction induces a large change in the lattice parameters a and b^* , the variation in c is an order of magnitude smaller. For all three directions, the change is linear in ε_a with a slope of $0.05 \text{ \AA}/\%$, $-0.01 \text{ \AA}/\%$, and $-0.002 \text{ \AA}/\%$ for a , b^* , and c , respectively. This difference suggests that a much larger stress must be applied along the c axis (z direction) to induce an observable effect in the AHE.

A comparison of the c/a ratio under hydrostatic pressure (taken from [34]) and uniaxial stress applied along the a direction is shown in Fig. 2. Under hydrostatic pressure, the ratio c/a varies linearly with pressure up to about 1.8 GPa. Beyond this pressure, c/a remains constant due to a magnetostriction effect induced by the out-of-plane canting of the magnetic structure [18,34]. When uniaxial stress is applied along the a direction, the resulting strain, which ranges from -0.17% compressive to 0.07% tensile, leads to a c/a ratio that is linear in ε_a . The linear dependence is consistent with the linear range observed under hydrostatic pressure. This allows us to directly compare the AHE data obtained under hydrostatic pressure and uniaxial stress based on the changes in lattice structure.

We now turn to the strain evolution of the AHE. The antisymmetrized Hall resistivity ρ_{zy} , plotted for increasing field, under stress applied perpendicular to the kagome plane along the z axis at 10 K and 200 K is presented in Fig. 3. ρ_{zy} shows a significant anomalous Hall effect with a steplike change from positive values at negative fields to negative values at positive fields. The ordinary Hall effect is small. It is negligible compared to the total Hall signal (see the

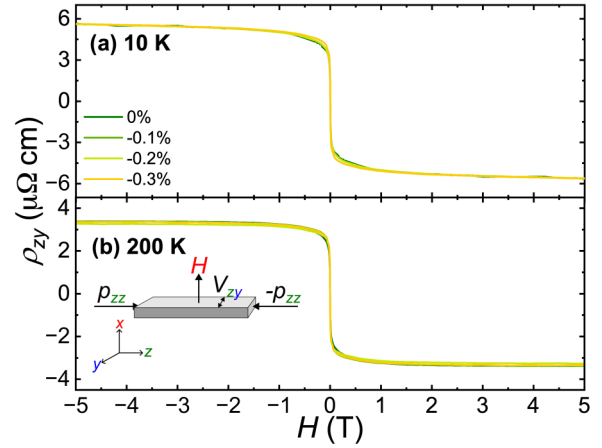


FIG. 3. Hall resistivity ρ_{zy} of Mn_3Ge under compressive stress applied along the z axis at (a) 10 K and (b) 200 K. The field was applied along the y axis and the data was recorded with an increasing magnetic field. The zero-strain curves were measured separately outside of the strain cell.

Appendix). Applying stress does not lead to significant changes in the AHE for compressive strains up to -0.3% . At 200 K we find saturation of the Hall resistivity at $|\rho_{zy}^{\text{sat}}| \approx 5.6 \mu\Omega \text{ cm}$ for high magnetic fields, while at 10 K ρ_{zy} tends to saturate but still shows a finite slope at $\pm 5 \text{ T}$. At $\pm 5 \text{ T}$ we find $|\rho_{zy}^{\text{sat}}| \approx 3.4 \mu\Omega \text{ cm}$. The finding that the AHE is insensitive to stress applied along the z axis in Mn_3Ge is in contrast to hydrostatic pressure experiments where the Hall resistivity is probed in the same measurement configuration (see Fig. 3), but is consistent with results on the closely related material Mn_3Sn [27], which is also insensitive to out-of-plane stress.

In contrast to out-of-plane stress, in-plane stress has a strong effect on the AHE. Figure 4 shows the antisymmetrized

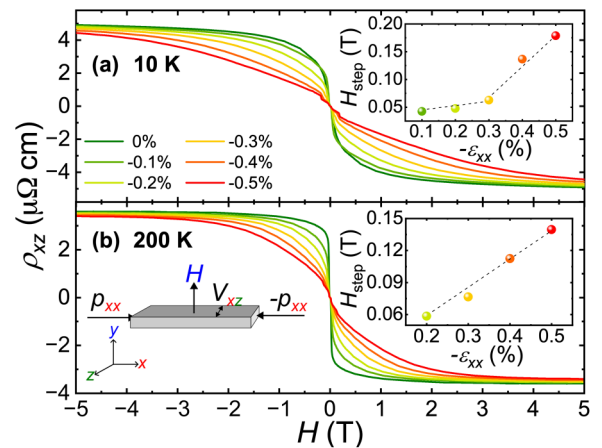


FIG. 4. Hall resistivity ρ_{xz} of Mn_3Ge under compressive stress applied along the x axis at (a) 10 K and (b) 200 K. The magnetic field was applied along the y direction and the data was recorded with an increasing magnetic field. The zero-strain curve at 10 K was measured separately outside of the strain cell. The insets display the positions of the steplike features observed at low magnetic fields as a function of compressive strain. The dotted lines serve as a guide to the eye.

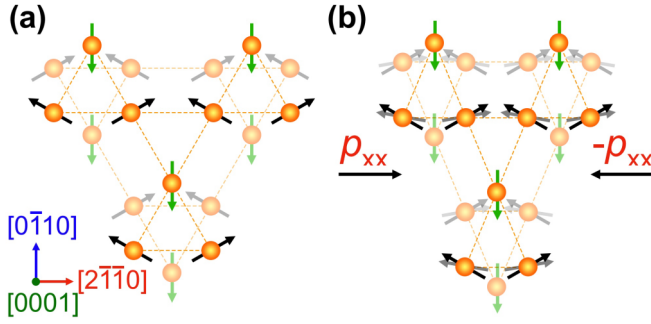


FIG. 5. (a) Magnetic structure of Mn_3Ge for a magnetic field applied along the $[0\bar{1}10]$ direction. The black and green arrows represent the anti-chiral antiferromagnetic structure. When the field direction is reversed, the spins flip 180° [30]. The green arrows correspond to the moments aligned with the local easy axis [31]. (b) Stress induces an additional easy axis along the stress application, which induces the spins to rotate towards such axis.

ρ_{xz} in applied magnetic field between -5 T and 5 T under different compressive stresses applied along the x direction for 10 K and 200 K. At zero strain, $\rho_{xz}(H)$ shows a similar behavior as described above for $\rho_{zy}(H)$. ρ_{xz} is positive for negative fields and shows a steplike feature at zero field, with the signal reversing at positive fields. However, especially at low temperatures, the step is not as sharp as in $\rho_{zy}(H)$. In addition, we find a clear strain dependence of the AHE for both temperatures. At 10 K, the Hall resistivity saturates around $|\rho_{xz}^{\text{sat}}| \approx 4.5 \mu\Omega \text{ cm}$ above ± 2 T. Increasing compressive strain shifts the field above which $\rho_{xz}(H)$ saturates to higher values, while simultaneously broadening the step in the AHE signal. At maximum strain we find an almost linear field dependence of ρ_{xz} around zero field. $|\rho_{xz}^{\text{sat}}|$ drops from about $4.9 \mu\Omega \text{ cm}$ at zero strain to $4.4 \mu\Omega \text{ cm}$ at -0.5% compressive strain at 5 T. At 1 T, the value drops from $|\rho_{xz}^{\text{sat}}| \approx 4 \mu\Omega \text{ cm}$ to $1.7 \mu\Omega \text{ cm}$ in the same strain range. This behavior seems to be in contrast to that observed under hydrostatic pressure, where increasing pressure leads to an inversion of the AHE signal around 1.53 GPa, at which pressure the AHE signal disappears [18].

At 10 K, a prominent kink appears in the Hall resistivity curve around ± 0.04 T. This kink shifts monotonically to higher fields with increasing strain. The field position of these kinks (H_{step}) as a function of compressive strain is shown in the inset of Fig. 4(a). A similar feature can be observed at 200 K starting at -0.2% strain at about ± 0.06 T [inset Fig. 4(b)]. Although not as pronounced as at 10 K, there is a linear shift to higher fields with increasing strain. The possible origin of this feature is discussed below.

IV. DISCUSSION

Mn_3Ge has a ground state magnetic structure where the local moments are arranged in an AFM antichiral 120° triangular configuration [see Fig. 5(a)] driven by Heisenberg exchange interactions between nearest neighbors [36,37]. The chirality of this arrangement is determined by a Dzyaloshinskii-Moriya (DM) interaction [38,39]. This interaction constrains the spins to lie within the kagome plane, with no discernible canting along the c axis. The Ge site introduces a weak local easy-axis anisotropy that is significantly smaller

than both the exchange and DM interactions. This anisotropy perturbs the 120° spin configuration in the kagome plane, resulting in a small dipolar FM moment of about $10^{-3} \mu_B$ per Mn atom [25]. In our samples, this residual moment induces a small hysteresis in ρ_{xz} , with a coercive field of 200 Oe at 200 K. This result is in excellent agreement with that reported in Ref. [30]. The hysteresis observed in ρ_{zy} is much smaller, with a coercive field of 70 Oe at 200 K, indicating a negligible out-of-plane component of the magnetic moment. However, the small FM in-plane moment has been shown not to play a role in the origin of the AHE [8]. Previous studies of the angular dependence of the AHE have shown that this residual magnetic moment, as well as the applied field, solely changes the chirality of the spin structure [8,37].

A secondary local easy axis points from the Mn sites toward the center of each triangle [31]. Due to the dominant exchange interaction J , neighboring spins are locked into a specific pattern, effectively fixing the orientation of the three-spin arrangement in each triangle. Consequently, the order parameter of the system can be described as a vector representing this locked spin configuration. This local symmetry corresponds to the D_{3h} group. Its irreducible representation gives rise to six magnetic modes: three in-plane modes ($\alpha_0, \alpha_x, \alpha_y$) and three out-of-plane modes ($\beta_0, \beta_x, \beta_y$) [25,31].

The magnetic ground state of Mn_3Ge at ambient pressure corresponds to six of the twelve possible minima of the in-plane α_0 mode, which corresponds to uniform rotations of the three spins within the sublattice and does not result in net magnetization per sublattice [25,31]. These sixfold Mn_3Ge ground states are those in which one of the spins points toward the local easy axis, i.e., toward the center of the triangles of the kagome lattice [34,40,41]. Application of magnetic field reduces the sixfold degeneracy of the α_0 mode to a twofold degeneracy, depending on the field direction [30]. This reduction accounts for the steplike signal inversion of the AHE at zero magnetic field observed in our data at ambient pressure (see Figs. 3 and 4).

When hydrostatic pressure is applied, the c/a ratio increases linearly up to about 1.8 GPa (see Fig. 2) [34]. In this regime, the AHE signal is continuously suppressed until it disappears at about 1.5 GPa and the AHE signal reverses and starts to increase again [18]. This behavior of the AHE is attributed to a change in the magnetic structure of Mn_3Ge , where the Mn spins rotate uniformly out of the plane and acquire a component along the c direction, i.e., hydrostatic pressure favors the β_0 mode [25,34], modifying the nonzero Berry curvature.

However, applying uniaxial stress along the a axis does not suppress the AHE signal, although the c/a ratio exhibits a linear dependence on uniaxial strain ε_a and, as shown in Fig. 2, this c/a ratio can be mapped directly onto the data obtained under hydrostatic pressure, indicating similar effects on the crystal structure. Nevertheless, the different responses of the AHE signal to hydrostatic pressure and uniaxial stress suggest that the resulting changes in magnetic structure are fundamentally different, even though the crystal structure is affected in a similar way.

Uniaxial stress introduces an additional easy-axis anisotropy that modifies the magnetic ground state by changing the Heisenberg exchange parameter due to lattice

displacements. In-plane strain distorts the 120° spin arrangement and generates a strain-dependent net in-plane moment. The intrinsic part of the Hall conductivity tensor is coupled to the Berry curvature via the Hall vector, which acts as a fictitious magnetic field in momentum space [42]. As shown by Dasgupta [25], the α_0 magnetic mode is linearly coupled to the Hall vector, allowing manipulation of the 120° spin configuration to influence the Hall effect.

In contrast to hydrostatic pressure, which forces the spins out of the basal plane resulting in the β_0 mode [34], uniaxial stress is expected to modify the anisotropy energy scale and tune the AHE by rotating the spins only in-plane without inducing tilting along the z direction [25]. An illustration of this effect is shown in Fig. 5(b). Moreover, the steps observed in the AHE at low magnetic fields, shown in the insets of Fig. 4, can be explained by the degeneracy breaking of the α_0 mode, which depends on the anisotropy energy scale [27]. As the anisotropy increases with strain, this degeneracy breaking field shifts almost linearly to higher magnetic fields.

The results obtained on Mn_3Ge can be compared to those of the closely related compound Mn_3Sn , which exhibits a similar strain dependent AHE [27]. This compound has the same crystal structure as Mn_3Ge , but is proposed to have a different magnetic ground state. While the proposed degenerate magnetic ground state of Mn_3Ge corresponds to six of the twelve minima of the α_0 mode mentioned above, that of Mn_3Sn corresponds to the remaining six configurations [25,31]. In Mn_3Sn the local easy axis does not point to the center of the triangular sublattice as in Mn_3Ge , but is aligned along the a direction [31].

AHE data taken on Mn_3Sn at room temperature in the same geometry as used here [see Fig. 1(a)] also revealed a strong dependence of the AHE on strain. A signal inversion of the AHE was observed between strains of -0.062% and -0.21% . In contrast, theoretical predictions from Ref. [25] suggest that Mn_3Ge should exhibit a similar signal inversion at about half of this strain range. However, direct comparison of strain values is not straightforward due to intrinsic material differences. It is known that hexagonal Mn_3Ge is only stable with excess Mn randomly occupying the Ge site [30,43]. This can lead to variations in electronic structure and magnetic anisotropy that affect how strain modifies the band structure and associated Berry curvature. Experimental uncertainties in cell calibration and efficiency of stress transfer to the sample may also be a factor. This needs to be considered when interpreting strain-dependent phenomena in different materials, even within the same structural family. Although the theoretical prediction of Ref. [25] suggests that stress applied along the c axis should have a similar effect as in-plane stress, the elastic moduli of both compounds differ significantly between in-plane and out-of-plane directions. Mn_3Ge has a c axis elastic modulus that is 2.3 times larger than the in-plane modulus one, with a nominal Poisson's ratio ν_{ca} of 0.041 [35]. Our measured value, $\nu_{ca} = 0.035(1)$, is in reasonable agreement with the theoretical value.

V. CONCLUSION

In conclusion, our study of the effect of uniaxial stress on the crystal structure and AHE in Mn_3Ge reveals a complex

interplay between strain, magnetic structure, and electronic properties. We find that uniaxial stress applied along the a axis significantly modifies the AHE, while stress along the c axis has a negligible effect. This difference is attributed to the different effects of in-plane and out-of-plane stress on the magnetic structure, with in-plane stress distorting the 120° spin arrangement and generating a strain-dependent net in-plane moment. Our results contrast with those obtained under hydrostatic pressure, where the AHE is reversed. The strain-dependent AHE in Mn_3Ge is consistent with theoretical predictions and observations in Mn_3Sn . Our results highlight the importance of considering the specific effects of strain on the magnetic structure and electronic transport properties, which are crucial for the design of advanced spintronic devices with tailored properties. The ability to precisely control the AHE through uniaxial strain could enable the development of high-performance magnetic sensors and memory devices with enhanced sensitivity and stability, highlighting the potential of strain engineering in spintronics.

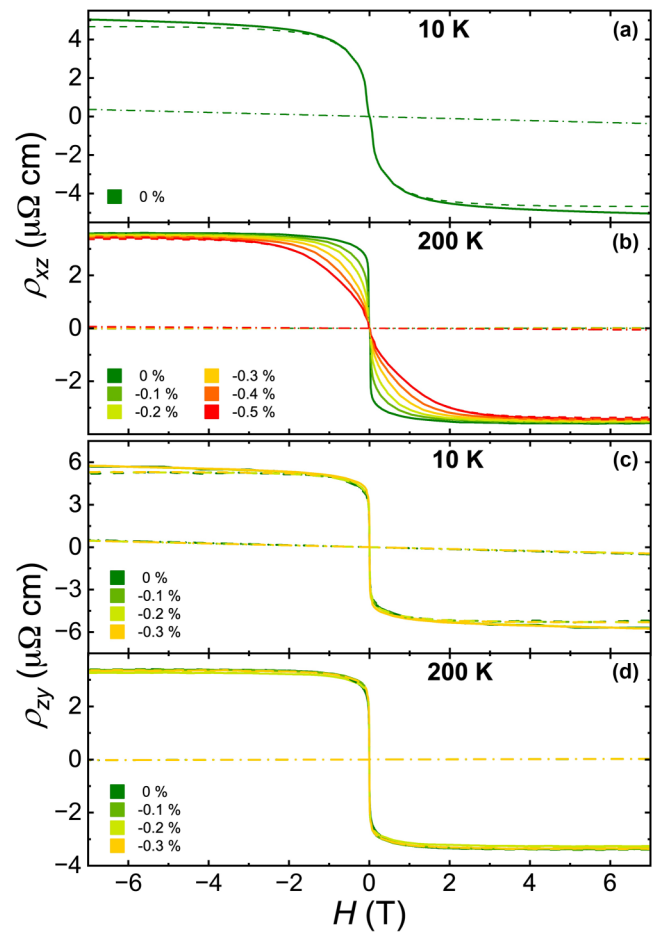


FIG. 6. Anomalous Hall resistivity (dashed lines) derived by subtracting the ordinary Hall contribution (dashed-dotted lines) from the total Hall signal (solid lines). Panels (a) and (b) correspond to measurements with current and stress applied along the x axis and the magnetic field along the y axis. Panels (c) and (d) show data with current and stress applied along the z axis and a magnetic field along the x axis.

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DATA AVAILABILITY

The data that support the findings of this article are openly available [44].

APPENDIX

The contribution of the ordinary Hall effect to the total Hall effect is small in Mn_3Ge . To separate the contributions of the ordinary and anomalous Hall effects, we performed a linear fit in the saturation region of the Hall signal at high magnetic fields, as described in Ref. [45]. We applied the linear fit to the field range between 6 T and 9 T and subtracted the resulting ordinary Hall effect contribution from the total Hall signal. Figure 6 shows the total, anomalous, and ordinary Hall contributions for the two investigated components, ρ_{xz} and ρ_{zy} , at 10 K and 200 K. Note that we lack data above 5 T for ρ_{xz} at 10 K, except at zero strain, which prevents an exact estimation of the ordinary Hall component.

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- [1] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, and A. A. Firsov, Electric field effect in atomically thin carbon films, *Science* **306**, 666 (2004).
 - [2] C. Chappert, A. Fert, and F. N. Van Dau, The emergence of spin electronics in data storage, *Nat. Mater.* **6**, 813 (2007).
 - [3] A. D. Kent and D. C. Worledge, A new spin on magnetic memories, *Nat. Nanotechnol.* **10**, 187 (2015).
 - [4] M. M. Waldrop, The chips are down for Moore's law, *Nature (London)* **530**, 144 (2016).
 - [5] E. Liu, Y. Sun, N. Kumar, L. Muechler, A. Sun, L. Jiao, S.-Y. Yang, D. Liu, A. Liang, Q. Xu, J. Kroder, V. Süß, H. Borrmann, C. Shekhar, Z. Wang, C. Xi, W. Wang, W. Schnelle, S. Wirth, Y. Chen *et al.*, Giant anomalous Hall effect in a ferromagnetic kagome-lattice semimetal, *Nat. Phys.* **14**, 1125 (2018).
 - [6] S. V. Faleev, Y. Ferrante, J. Jeong, M. G. Samant, B. Jones, and S. S. P. Parkin, Heusler compounds with perpendicular magnetic anisotropy and large tunneling magnetoresistance, *Phys. Rev. Mater.* **1**, 024402 (2017).
 - [7] T. Jungwirth, J. Sinova, A. Manchon, X. Marti, J. Wunderlich, and C. Felser, The multiple directions of antiferromagnetic spintronics, *Nat. Phys.* **14**, 200 (2018).
 - [8] A. K. Nayak, J. E. Fischer, Y. Sun, B. Yan, J. Karel, A. C. Komarek, C. Shekhar, N. Kumar, W. Schnelle, J. Kübler, C. Felser, and S. S. P. Parkin, Large anomalous Hall effect driven by a nonvanishing Berry curvature in the noncolinear antiferromagnet Mn_3Ge , *Sci. Adv.* **2**, e1501870 (2016).
 - [9] P. Wadley, B. Howells, J. Železný, C. Andrews, V. Hills, R. P. Campion, V. Novák, K. Olejník, F. Maccherozzi, S. S. Dhesi, S. Y. Martin, T. Wagner, J. Wunderlich, F. Freimuth, Y. Mokrousov, J. Kuneš, J. S. Chauhan, M. J. Grzybowski, A. W. Rushforth, K. W. Edmonds *et al.*, Electrical switching of an antiferromagnet, *Science* **351**, 587 (2016).
 - [10] X. Hu, Half-metallic antiferromagnet as a prospective material for spintronics, *Adv. Mater.* **24**, 294 (2012).
 - [11] K. Manna, Y. Sun, L. Muechler, J. Kübler, and C. Felser, Heusler, Weyl and Berry, *Nat. Rev. Mater.* **3**, 244 (2018).
 - [12] T. Jungwirth, X. Marti, P. Wadley, and J. Wunderlich, Antiferromagnetic spintronics, *Nat. Nanotechnol.* **11**, 231 (2016).
 - [13] V. Baltz, A. Manchon, M. Tsoi, T. Moriyama, T. Ono, and Y. Tserkovnyak, Antiferromagnetic spintronics, *Rev. Mod. Phys.* **90**, 015005 (2018).
 - [14] H. Yan, Z. Feng, S. Shang, X. Wang, Z. Hu, J. Wang, Z. Zhu, H. Wang, Z. Chen, H. Hua *et al.*, A piezoelectric, strain-controlled antiferromagnetic memory insensitive to magnetic fields, *Nat. Nanotechnol.* **14**, 131 (2019).
 - [15] A. Hirohata, Advances in antiferromagnetic spintronics, *Magnetochemistry* **8**, 37 (2022).
 - [16] A. Dal Din, O. Amin, P. Wadley, and K. Edmonds, Antiferromagnetic spintronics and beyond, *npj Spintronics* **2**, 25 (2024).
 - [17] D. Xiong, Y. Jiang, K. Shi, A. Du, Y. Yao, Z. Guo, D. Zhu, K. Cao, S. Peng, W. Cai, D. Zhu, and W. Zhao, Antiferromagnetic spintronics: An overview and outlook, *Fundam. Res.* **2**, 522 (2022).
 - [18] R. D. dos Reis, M. G. Zavareh, M. Ajeesh, L. Kutelak, A. Sukhanov, S. Singh, J. Noky, Y. Sun, J. Fischer, K. Manna *et al.*, Pressure tuning of the anomalous Hall effect in the chiral antiferromagnet Mn_3Ge , *Phys. Rev. Mater.* **4**, 051401(R) (2020).
 - [19] P. E. Faria Junior, K. A. de Mare, K. Zollner, K.-H. Ahn, S. I. Erlingsson, M. van Schilfhaarde, and K. Výborný, Sensitivity of the MnTe valence band to the orientation of magnetic moments, *Phys. Rev. B* **107**, L100417 (2023).
 - [20] T. Aoyama and K. Ohgushi, Piezomagnetic properties in alternating magnetic MnTe, *Phys. Rev. Mater.* **8**, L041402 (2024).
 - [21] M. Mojarro and S. E. Ulloa, Tuning electronic pairing by uniaxial strain in kagome lattices, *Phys. Rev. B* **110**, 235129 (2024).
 - [22] C. Lin, A. Consiglio, O. K. Forslund, J. Küspert, M. M. Denner, H. Lei, A. Louat, M. D. Watson, T. K. Kim, C. Cacho *et al.*, Uniaxial strain tuning of charge modulation and singularity in a kagome superconductor, *Nat. Commun.* **15**, 10466 (2024).

- [23] D. Zhang, B. Yan, S.-C. Wu, J. Kübler, G. Kreiner, S. S. P. Parkin, and C. Felser, First-principles study of the structural stability of cubic, tetragonal and hexagonal phases in Mn_3Z ($\text{Z}=\text{Ga}$, Sn and Ge) Heusler compounds, *J. Phys.: Condens. Matter* **25**, 206006 (2013).
- [24] T. Ohoyama, X-ray and magnetic studies of the manganese-germanium system, *J. Phys. Soc. Jpn.* **16**, 1995 (1961).
- [25] S. Dasgupta, Tuning the transport properties of Mn_3Ge through the effect of strain on its magnetism, *Phys. Rev. B* **106**, 064431 (2022).
- [26] G. Chaudhary, A. A. Burkov, and O. G. Heinonen, Magnetism and magnetotransport in the kagome antiferromagnet Mn_3Ge , *Phys. Rev. B* **105**, 085108 (2022).
- [27] M. Ikhlas, S. Dasgupta, F. Theuss, T. Higo, S. Kittaka, B. Ramshaw, O. Tchernyshyov, C. Hicks, and S. Nakatsuji, Piezomagnetic switching of the anomalous Hall effect in an antiferromagnet at room temperature, *Nat. Phys.* **18**, 1086 (2022).
- [28] X. Wang, Z. Feng, P. Qin, H. Yan, X. Zhou, H. Guo, Z. Leng, W. Chen, Q. Jia, Z. Hu *et al.*, Integration of the noncollinear antiferromagnetic metal Mn_3Sn onto ferroelectric oxides for electric-field control, *Acta Mater.* **181**, 537 (2019).
- [29] H. Guo, Z. Feng, H. Yan, J. Liu, J. Zhang, X. Zhou, P. Qin, J. Cai, Z. Zeng, X. Zhang *et al.*, Giant piezospinronic effect in a noncollinear antiferromagnetic metal, *Adv. Mater.* **32**, 2002300 (2020).
- [30] N. Kiyohara, T. Tomita, and S. Nakatsuji, Giant anomalous Hall effect in the chiral antiferromagnet Mn_3Ge , *Phys. Rev. Appl.* **5**, 064009 (2016).
- [31] S. Dasgupta and O. Tchernyshyov, Theory of spin waves in a hexagonal antiferromagnet, *Phys. Rev. B* **102**, 144417 (2020).
- [32] R. D. dos Reis, U. F. Kaneko, B. A. Francisco, J. Fonseca Jr., M. A. S. Eleoterio, and N. M. Souza-Neto, Preliminary overview of the extreme condition beamline (EMA) at the new Brazilian synchrotron source (Sirius), *J. Phys.: Conf. Ser.* **1609**, 012015 (2020).
- [33] C. W. Hicks, M. E. Barber, S. D. Ekins, D. O. Brodsky, and A. P. Mackenzie, Piezoelectric-based apparatus for strain tuning, *Rev. Sci. Instrum.* **85**, 065003 (2014).
- [34] A. Sukhanov, S. Singh, L. Caron, T. Hansen, A. Hoser, V. Kumar, H. Borrmann, A. Fitch, P. Devi, K. Manna, C. Felser, and D. S. Inosov, Gradual pressure-induced change in the magnetic structure of the noncollinear antiferromagnet Mn_3Ge , *Phys. Rev. B* **97**, 214402 (2018).
- [35] F. Theuss, S. Ghosh, T. Chen, O. Tchernyshyov, S. Nakatsuji, and B. Ramshaw, Strong magnetoelastic coupling in Mn_3X ($\text{X} = \text{Ge}$, Sn), *Phys. Rev. B* **105**, 174430 (2022).
- [36] T. Nagamiya, Triangular spin ordering in Mn_3Sn and Mn_3Ge , *J. Phys. Soc. Jpn.* **46**, 787 (1979).
- [37] T. Nagamiya, S. Tomiyoshi, and Y. Yamaguchi, Triangular spin configuration and weak ferromagnetism of Mn_3Sn and Mn_3Ge , *Solid State Commun.* **42**, 385 (1982).
- [38] I. Dzyaloshinsky, A thermodynamic theory of “weak” ferromagnetism of antiferromagnetics, *J. Phys. Chem. Solids* **4**, 241 (1958).
- [39] T. Moriya, Anisotropic superexchange interaction and weak ferromagnetism, *Phys. Rev.* **120**, 91 (1960).
- [40] S. Tomiyoshi, Y. Yamaguchi, and T. Nagamiya, Triangular spin configuration and weak ferromagnetism of Mn_3Ge , *J. Magn. Magn. Mater.* **31-34**, 629 (1983).
- [41] J.-R. Soh, F. De Juan, N. Qureshi, H. Jacobsen, H.-Y. Wang, Y.-F. Guo, and A. Boothroyd, Ground-state magnetic structure of Mn_3Ge , *Phys. Rev. B* **101**, 140411 (2020).
- [42] N. Nagaosa, J. Sinova, S. Onoda, A. H. MacDonald, and N. P. Ong, Anomalous Hall effect, *Rev. Mod. Phys.* **82**, 1539 (2010).
- [43] N. Yamada, H. Sakai, H. Mori, and T. Ohoyama, Magnetic properties of $\varepsilon\text{-Mn}_3\text{Ge}$, *Physica B+C* **149**, 311 (1988).
- [44] G. A. Lombardi, Data for the manuscript entitled “Uniaxial stress tuning of the anomalous Hall effect in Mn_3Ge ” (2025), <https://doi.org/10.17617/3.UTH7RG>.
- [45] V. Rai, S. Jana, J. Perßon, and S. Nandi, Weyl points and anomalous transport effects tuned by the Fe doping in Mn_3Ge Weyl semimetal, *New J. Phys.* **26**, 033043 (2024).

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