

Introduction

Weyl semimetals host topological band crossings that can give rise to unconventional transport phenomena, including the anomalous Hall effect.

PrAlGe is a noncentrosymmetric magnetic Weyl semimetal whose magnetic ordering may influence its electronic transport. Studying its magnetic relaxation can reveal slow dynamics and possible glassy behavior.

Here, we investigate the time-dependent magnetization and Hall transport of PrAlGe to explore connections between its magnetic dynamics and electronic transport.

Experimental Methods

Sample Preparation

PrAlGe single crystals were grown using the flux-growth method, characterized by X-ray diffraction (XRD), and polished into a Hall-bar geometry for electrical transport measurements.

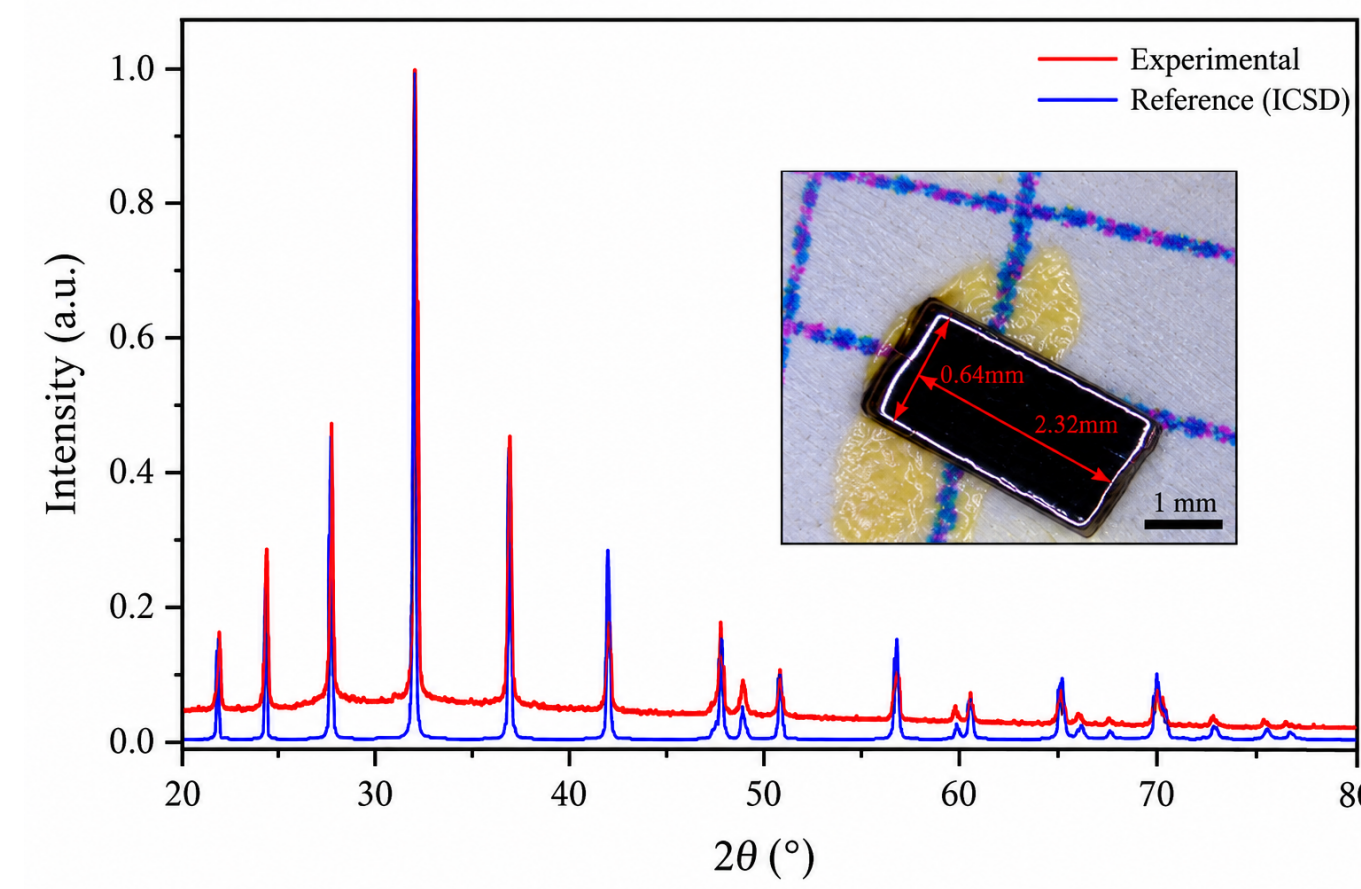


Figure 1. Powder X-ray diffraction (XRD) pattern of PrAlGe and photograph of the as-grown single crystal.

Magnetic Characterization

Instrument: Quantum Design DynaCool PPMS with VSM.

Measurements: Temperature-, field-, and time-dependent magnetization to investigate magnetic relaxation dynamics.

Electrical Transport Measurements

Measurements: Hall resistivity measured as a function of magnetic field at selected temperatures to investigate field and temperature dependence.

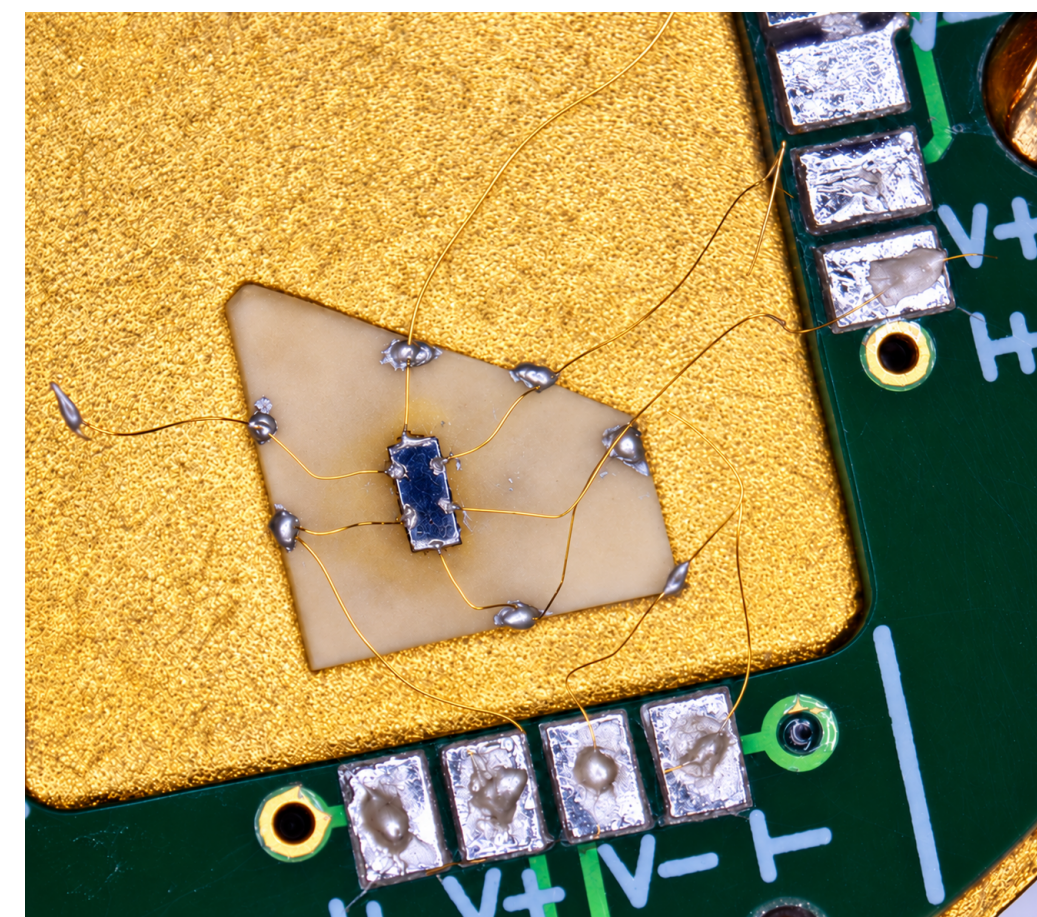
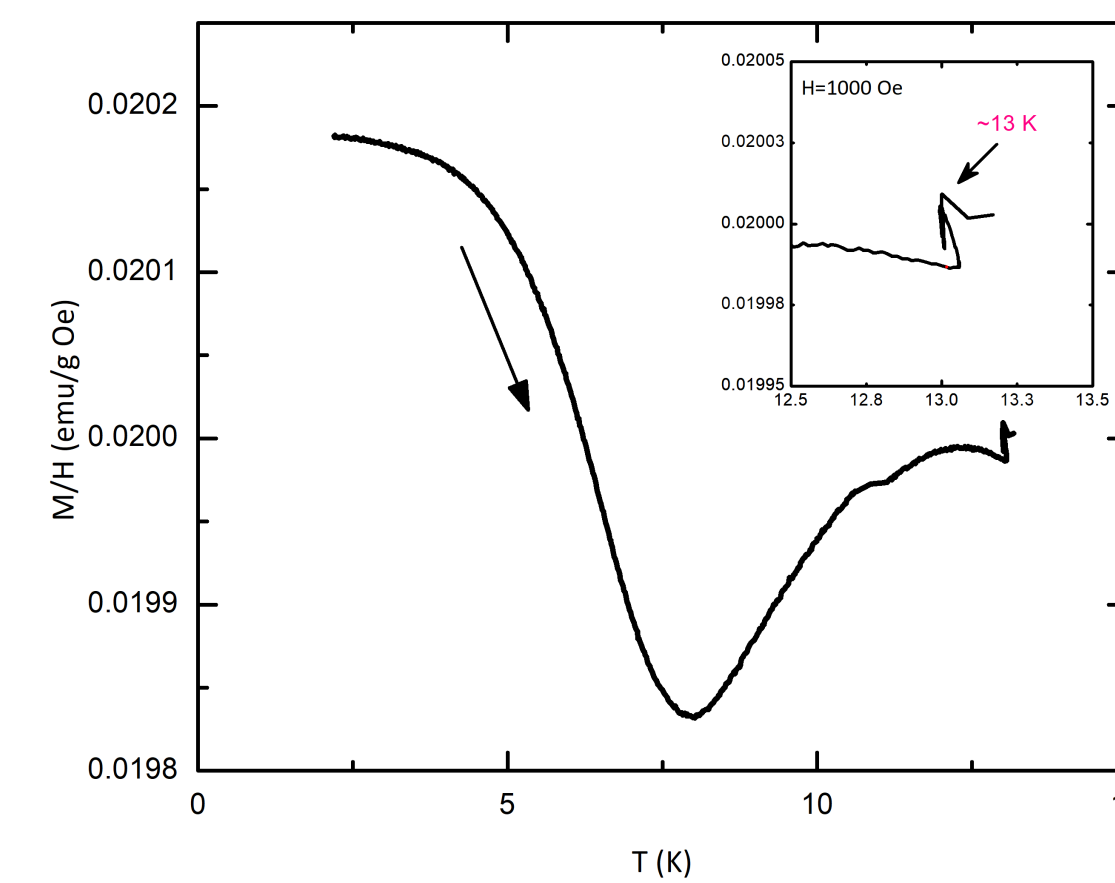


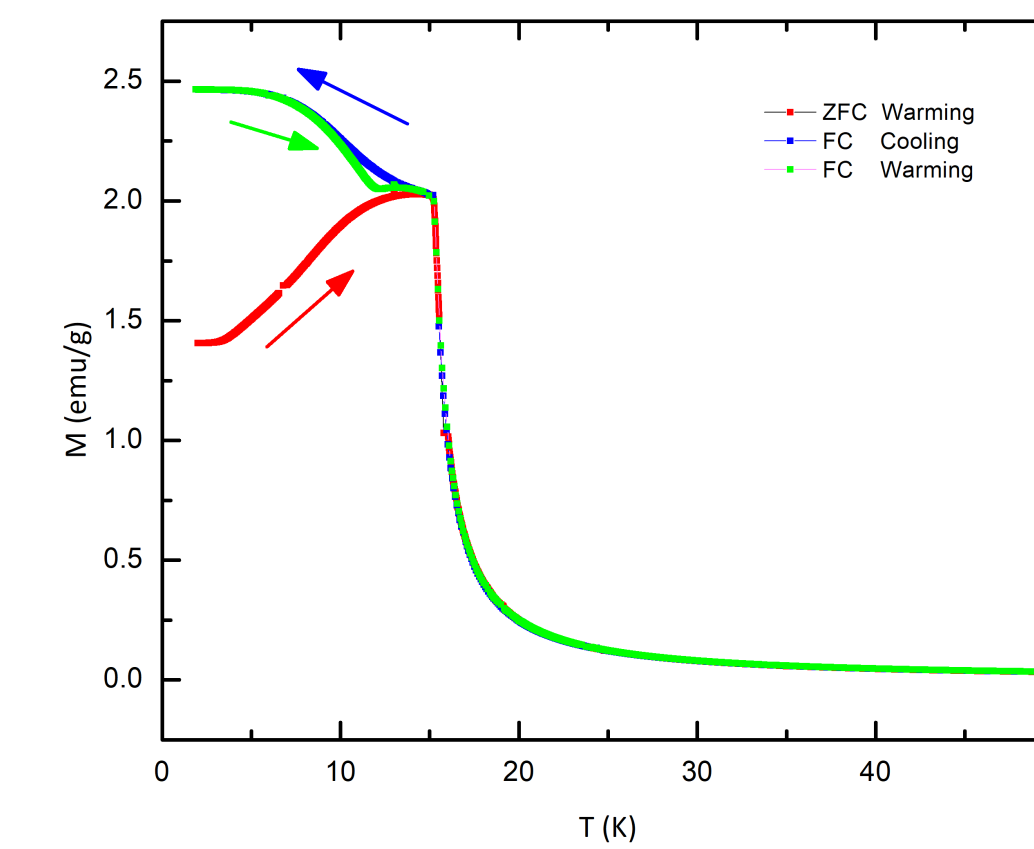
Figure 2. Photograph of the prepared PrAlGe Hall-bar device with electrical contacts for transport measurements.

Magnetic Properties and Relaxation

The low-temperature anomaly near 13 K at 1000 Oe motivated further investigation. ZFC–FC bifurcation below ~ 15 K indicates distinct magnetic behavior, prompting time-dependent relaxation measurements.

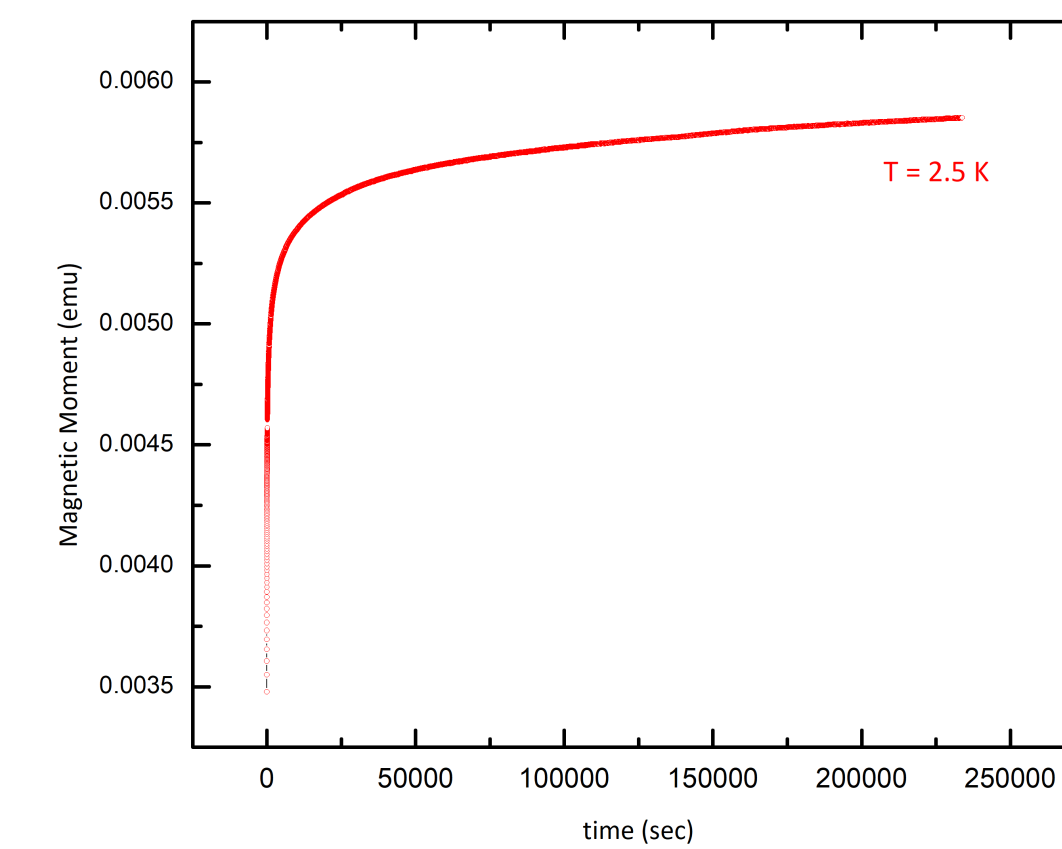


(a) the low-temperature magnetic anomaly at 1000 Oe.

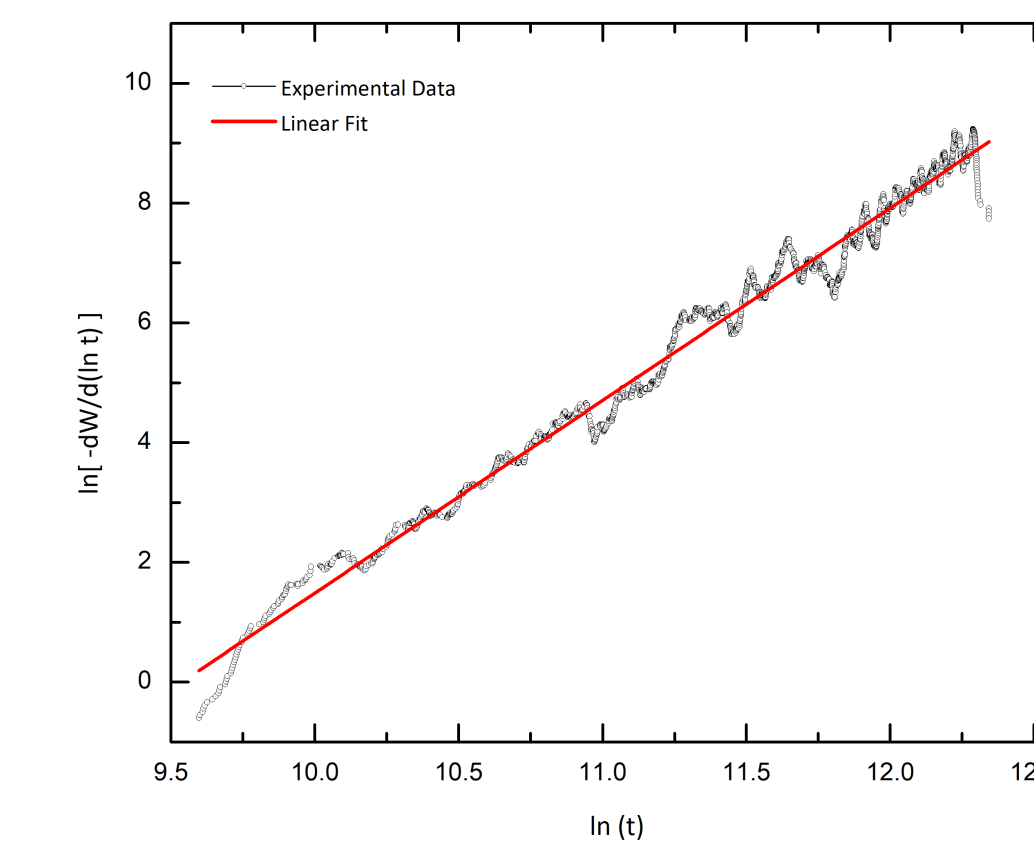


(b) ZFC and FC magnetization curves measured at 100 Oe, showing bifurcation below approximately 15 K.

To further investigate the magnetic dynamics below the bifurcation temperature, time-dependent magnetization was measured at 2.5 K under an applied field of 100 Oe. The relaxation curve was analyzed using a logarithmic transformation, yielding a linear-fit slope of 3.215 ± 0.009 (adjusted $R^2 = 0.9844$). The exponent β characterizes the relaxation profile in an appropriate exponential relaxation model; identifying it with the fitted slope requires validation of the model and transformation.



(c) Time-dependent magnetic moment of PrAlGe, showing the evolution of magnetization during relaxation.



(d) Linear fit to the transformed magnetic-relaxation data, $\ln[-dW/d \ln t]$ versus $\ln(t)$.

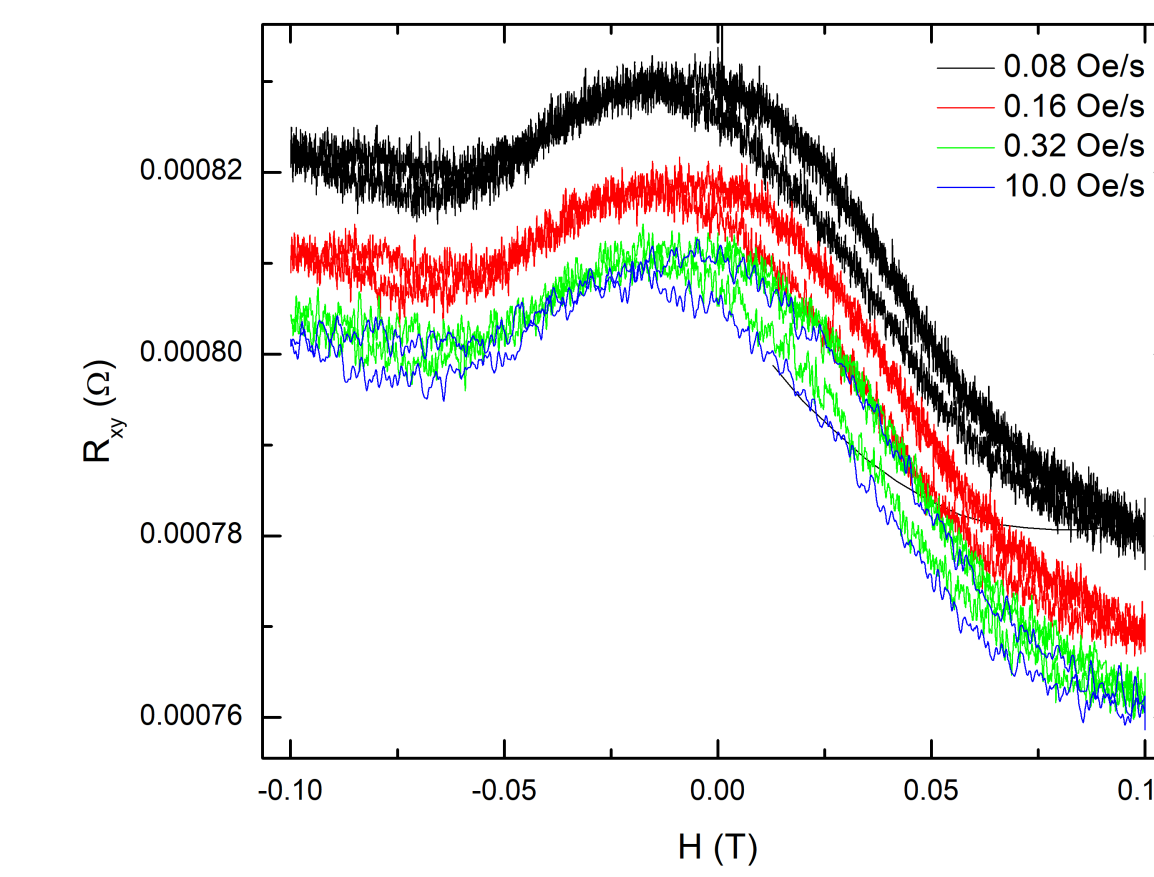
Figure 3. Magnetic properties and relaxation dynamics of PrAlGe.

The low-temperature anomaly and ZFC–FC bifurcation indicate distinct magnetic behavior below approximately 15 K. The time-dependent magnetization measurements provide a way to investigate the associated relaxation dynamics and assess the possibility of glassy magnetic behavior in PrAlGe.

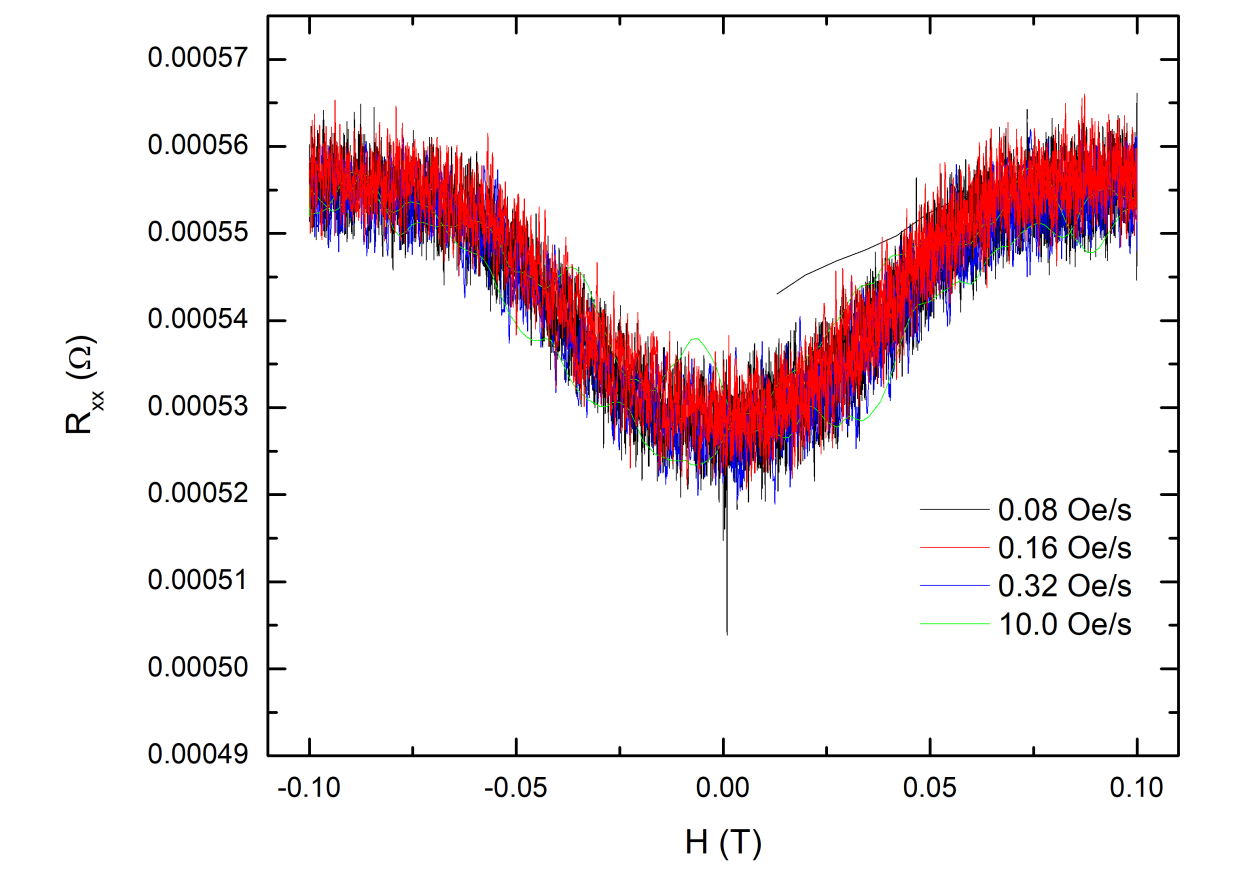
Hall and Longitudinal Transport

Field-dependent transverse and longitudinal resistance measurements were performed at 2 K and 13 K to investigate the field and temperature dependence of charge transport in PrAlGe.

Temperature comparison at 2 K



(a) Transverse resistance, $R_{xy}(H)$, at 2 K.

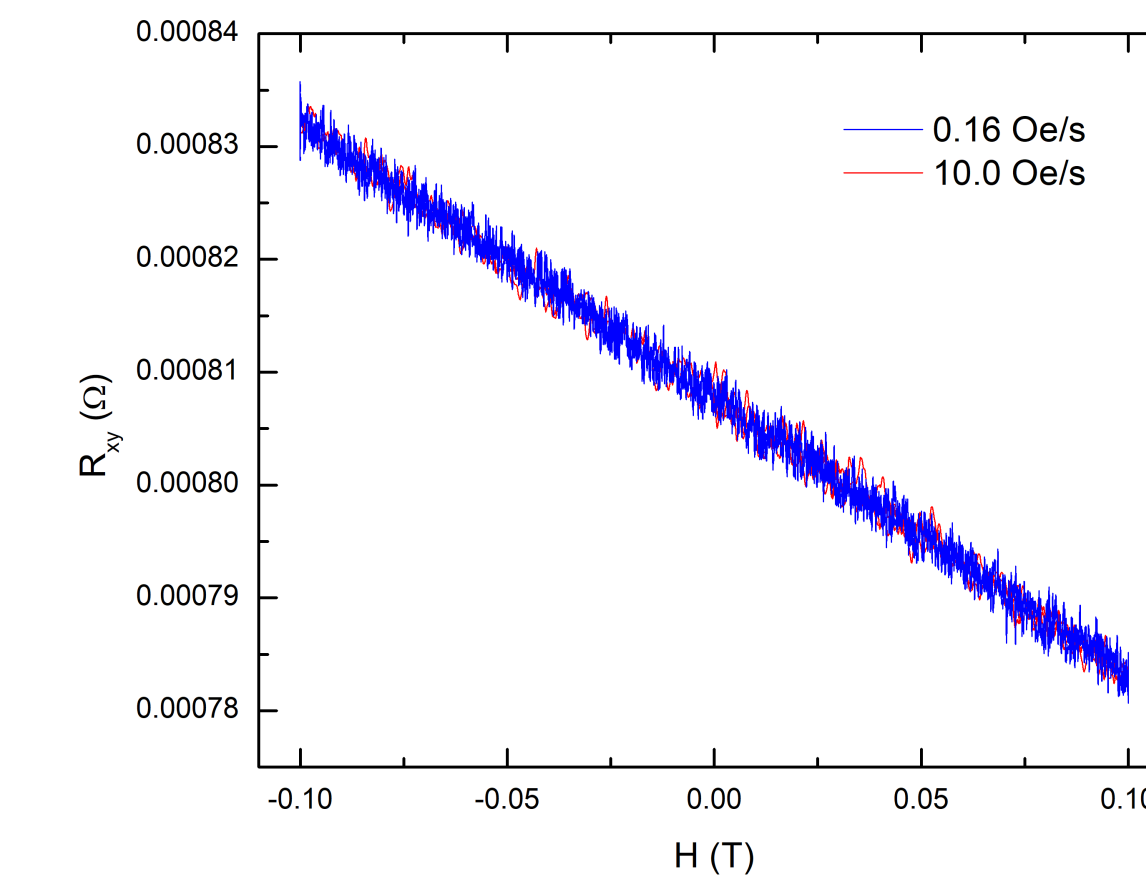


(b) Longitudinal resistance, $R_{xx}(H)$, at 2 K.

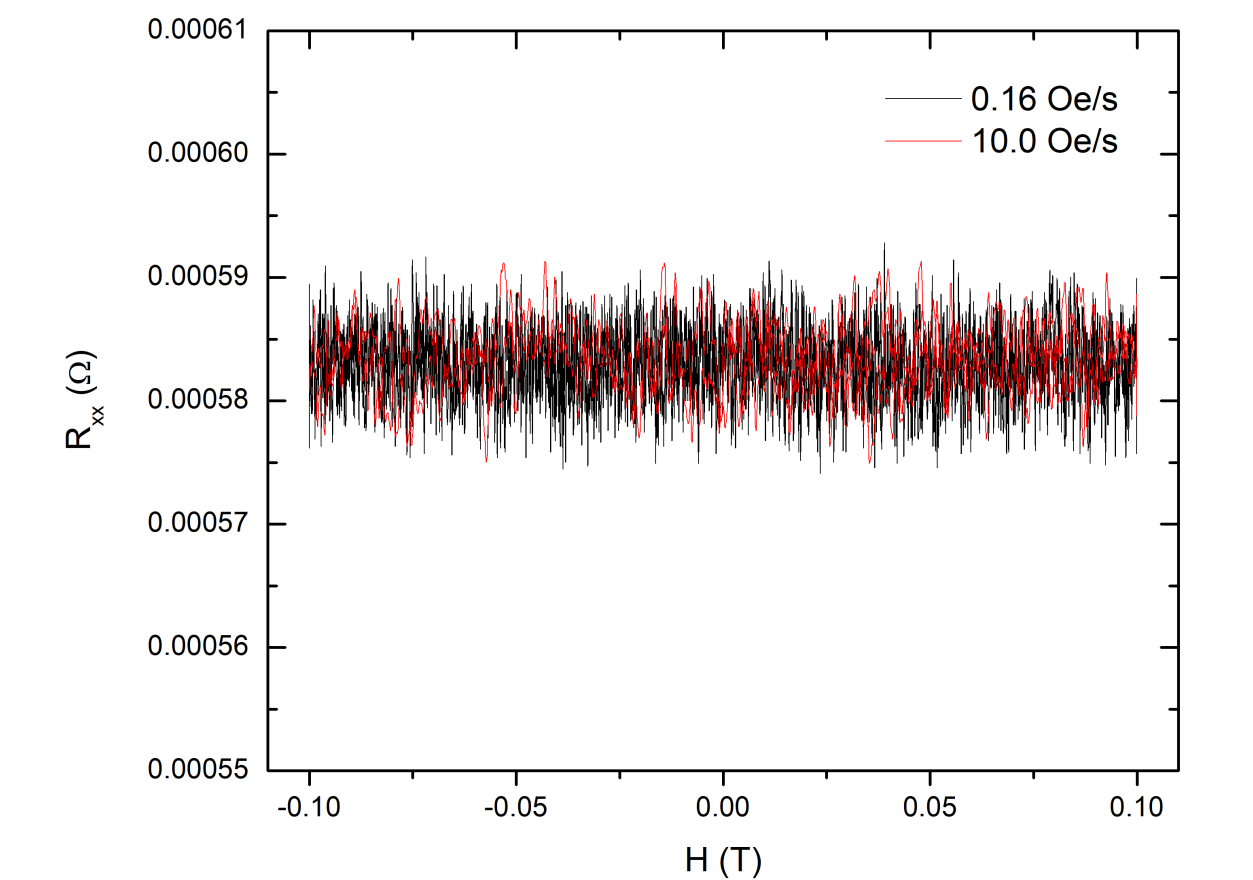
Figure 4. Field-dependent transverse and longitudinal resistance for different field-sweep rates, with $\tau = 3$ s.

At 2 K, the R_{xy} exhibits a pronounced field-dependent response across the measured sweep rates, while the R_{xx} shows no clearly resolvable sweep-rate dependence. Comparison with the 13 K measurements helps assess the temperature dependence of the transport response and the possible relationship between magnetic dynamics and Hall hysteresis. Longitudinal-resistance admixture must be considered before attributing the transverse signal to an intrinsic Hall response.

Temperature comparison at 13 K



(a) Transverse resistance, $R_{xy}(H)$, at 13 K.



(b) Longitudinal resistance, $R_{xx}(H)$, at 13 K.

Figure 5. Field-dependent transverse and longitudinal resistance for different field-sweep rates, with $\tau = 3$ s.

Conclusions

- Magnetism:** A low-temperature anomaly occurs near 13 K, with ZFC–FC bifurcation below approximately 15 K.
- Relaxation:** Time-dependent magnetization at 2.5 K probes the low-temperature magnetic dynamics.
- Transport at 2 K:** The transverse resistance shows a pronounced field-dependent response, while the longitudinal resistance shows no clearly resolvable sweep-rate dependence.
- Transport at 13 K:** No apparent hysteresis is observed in the measured transverse and longitudinal resistance curves.

Outlook: AC susceptibility, systematic relaxation studies, and assessment of longitudinal-resistance admixture will help clarify the magnetic dynamics and their relationship to electronic transport.