Magnetocrystalline anisotropy is a fundamental property of magnetic materials that determines the dynamics of magnetic precession, the frequency of spin waves, the thermal stability of magnetic domains, and the efficiency of spintronic devices. We combined torque magnetometry and density functional theory calculations to determine the magnetocrystalline anisotropy of the prototypical metallic antiferromagnet (AF) Fe$_2$As.

From experiment and computation, we find that the four-fold magnetocrystalline anisotropy $K_{22}$ of Fe$_2$As is surprisingly small and strongly temperature dependent. This impacts the development of thermally-stable information storage in easy-plane AFs, which will require the development of new materials having large anisotropy that persists to room temperature.

Conclusion: Understanding of magnetocrystalline anisotropy in metallic antiferromagnets enables research and development of novel antiferromagnetic memories.

The thermal stability of information stored in antiferromagnetic domains depends on the energy barrier that separates two degenerate orientations of the Neel vector. This energy barrier is determined by the dependence of the magnetic energy on the orientation of the Neel vector, i.e., the magnetocrystalline anisotropy. Cahill combined vibrating sample magnetometry and torque magnetometry to measure the magnetocrystalline anisotropy of the metallic antiferromagnet Fe$_2$As. Samples of Fe$_2$As were prepared and characterized by Shoemaker; modeling of the magnetic energy by Schleife was used to provide terms in the anisotropy that are not accessible to experiment and to explore the limits of computational approaches in determining the extremely small in-plane anisotropy of easy-please AF. The in-plane anisotropy is extremely small: even in the low temperature limit, the in-plane anisotropy is 4 orders of magnitude smaller than what is typically employed in ferromagnetic memory devices. Furthermore, the anisotropy nearly vanishes at $T$ greater than $\frac{1}{4}$ of the Neel temperature. These results suggest that AF-based memory will require the discovery of materials with significantly larger anisotropy and higher ordering temperatures.