



Colorado Science and Engineering Fair

2025 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: Emergent Quantum Inductance in Chiral Orbital Current State

Finalist's Name: Tristan Cao

School and City: Stargate School, Thornton

Sponsor's Name: Gang Cao

Category: Physics & Astronomy

Division: Senior (grades 9 - 12)

Abstract (250 words or less):

Chiral orbital currents (COC) circulating along the edges of the crystal unit cells underpin an array of novel phenomena in ferrimagnetic $\text{Mn}_3\text{Si}_2\text{Te}_6$. Two types of inductances are well known, namely, geometrical and kinetic inductance. The former arises from a changing magnetic flux inside a coil that generates an electromotive force (emf) to oppose the change; the latter results from the kinetic energy needed by each electron that contributes to a current flowing in a superconductor. Here we report a novel type of quantum inductance that originates from coherent COC enabled by a combined effect of a rising, low frequency alternating current (AC) and a constant magnetic field applied along the magnetic hard c axis. The coherent COC along with induced orbital moments rigidly couple to the lattice and act as an effective, atomic scale "coil" that induces a large emf in response to decreasing AC. The COC "coil" is also responsible for strong diamagnetic responses, which are unprecedented in any magnets, and a distinct drop in electrical resistivity below 5 K. The phenomenon of inductance is widely used in today's technology. The significance of this discovery cannot be overstated, both fundamentally and technologically.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature:

Date:

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES of all of these forms to your Regional Fair Director with you Finalist Verification/Permission Form. **A signed copy of this form must be included in your notebook.**