A laboratory-scale 2-axis tracking heliostat apparatus/solar concentrator for conceptual demonstrations of novel geoengineering innovations

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As the climate changes, planetary ecological systems and humanity face a series of threats, one of the most urgent and severe being extreme heat and thermal changes due to energy imbalances [1, 2]. Project MEER:reflEction seeks to create versatile mirror-based infrastructures to mitigate temperature extremes [3]. As a part of this effort, we design and build a small-scale heliostat apparatus with active sun-tracking capabilities that is immune to wind loads and low in construction requirements. The device reflects incoming sunlight and concentrates it to a focal point. We use a flat-plane concentrator (fresnel lens-style) approach, with an array of one hundred 2.5'' mirrors in a 1 m^2 rectangular grid, which are mounted on individually-angled 3d-printed blocks [4, 5]. The system uses a microcontroller and two stepper motors to angle the mirror array on the rotation and elevation axes, maintaining a desired stationary focal point as the sun moves across the sky [6]. The system is designed for a peak power of ~1kW under optimal conditions, enabling a maximum operating temperature of 900 degrees C. Our small-scale model focuses light into a reaction chamber to sustainably calcinate calcium carbonate in clamshells, a process that enables efficient capture of a pure CO_2 offgas stream [7]. The device is also intended to be a model for larger-scale heliostat apparatuses. We plan to make the design open-source, modular, and affordable, so that it can be created by DIYers and makers, inspiring people of all ages to learn about solar concentrators, mirrors, and novel solutions for climate change.

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Author Biographical Notes:

Mohan Hathi is a rising junior at the Cambridge Rindge and Latin School, in Cambridge, MA. He is deeply engaged with both STEM teaching and engineering and built a robotic spider movement platform for the Shamble Lab at Harvard last summer. He's excited to be building a solar concentrator with Dr. Tao and Chris Stokes as part of the MEER:reflEction team. In his spare time, he enjoys 3D printing, running cross-country and track, and singing Indian classical music.

Chris Stokes is a laboratory engineer at the Rowland Institute in Cambridge, MA. He has helped many scientists to further their experimental pursuits. Think Igor in Young Frankenstein.

Ye Tao is a principal investigator at the Rowland Institute at Harvard. He is formally trained in low-temperature experimental physics (mechanical detection of weak forces in scanned probe microscopy, Christian Degen, MIT and then ETH), mechanistic organic catalysis (Eric Jacobsen, Harvard), structural biology of RNA (Victoria D'Souza, Harvard), the mechanism of spontaneous crystal chiral symmetry breaking (Louis Cuccia, Concordia University), and combinatorial chemical syntheses (Olof Ramstrom, KTH). These various topics are unified by a desire to understand the relationships between the properties/behavior of a system and the atomic structural details of its constituents. Since starting an independent career in 2016, Dr. Tao's team has achieved important advances in nanotechnology, including the synthesis of the most magnetic oxide thin film (Ho_2O_3), demonstration of machining with atomic depth resolution, and the design of nanomechanical force sensors with properties beyond what had been possible. Dr. Tao is also founder of Project MEER:ReflEction, a new geoengineering framework with the potential to stop the ongoing ecological collapse on planet Earth that is projected to be wide-spread before or by 2050 on current trajectory.