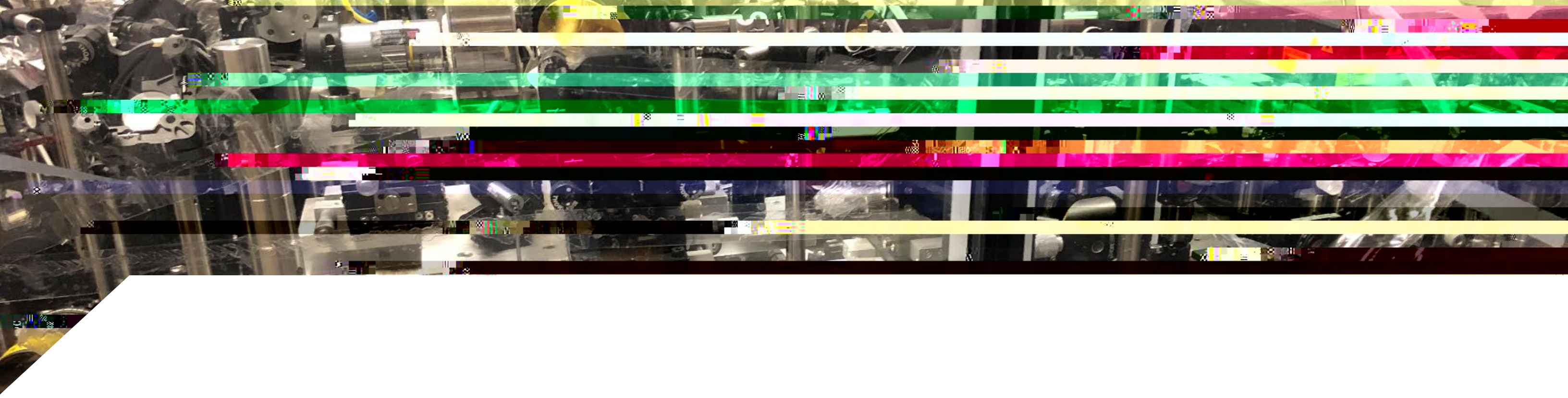

$_2$O), a potent greenhouse gas, and of nitrogen oxides (NOx) which are precursors to air pollution. The Berkeley team will develop a unique approach to understand and quantify N $_2$ fluxes and the associated drivers using a combination of isotope biogeochemistry, newly developed printable sensors, and atmospheric and biogeochemical modeling. A continuous $^{15}N_2O$ pool dilution approach using an isotope cavity ringdown spectrometer coupled to a photoacoustic spectrometer will be used to measure the movement of a $^{15}N_2$

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Today's digital technology uses binary logic with only two states: on or off. Imagine how society would be transformed if we had devices with thousands of logical states that are coupled together! Dramatic improvements in power consumption and density of computing elements can be achieved by multinary technology utilizing topologically protected ensembles of electron spins. While coupling and control of topological spin ensembles are inaccessible to standard probes, such as conventional light, this team of researchers from Rutgers University and the New Jersey Institute of Technology propose a new paradigm: using topological vortex light with orbital angular momentum (OAM). They hypothesize that only a probe with the topology, energy, and length scale matching the topological quantum spin ensembles can couple effectively to those spin ensembles. Vortex beams meet these requirements, and the team's initial discoveries in the THz energy range support this hypothesis. The researcher's objectives include creating, reading, and manipulating previously inaccessible quantum spin states with vortex beams using a wide range of OAM (up to a thousand). Examples include topologically-protected chiral spin textures, vortices, skyrmions, hopfions, and quantum Hall states with multi-valued topological indices. Specifically, they will attempt to: understand the mechanism of and optimize the coupling between THz, visible, and x-ray vortex beams and topological spin states; explore the dynamics of topological transitions in quantum spin states by vortex beams; and, attempt preliminary multinary device implementation of their scientific discoveries. This work is expected to have tremendous impact on its scientific field and society, opening new frontiers in quantum magnetism, enabling innovative multinary electronics, and influencing artificial intelligence.

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Predicting the crystal structures of molecules is an extraordinarily difficult problem that cannot be solved using thermodynamics alone. However, calculating crystallization kinetics is notoriously challenging. This work seeks to establish a new paradigm in crystal structure prediction that accounts for differences in the crystallization rates of molecular systems by focusing on the oligomeric species that they form in solution. The strategy tightly integrates computer simulations, analysis of crystal structures, experimental crystallization screenings, and spectroscopy. The overarching goal is to demonstrate that solution oligomers play an important role in the crystallization of typical organic molecules and that their inclusion in crystallization models can markedly improve crystal structure prediction based solely on energy landscapes. The main hypothesis is that decisive differences in polymorph formation kinetics can be estimated at moderate cost by