



Colorado State University

Fort Collins, CO

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\$1,200,000

The fundamental chemical and physical transformations that occur in buildings are poorly understood due to extreme complexity and variability across indoor environments. How molecules move between phases and chemically transform controls their reactivity and toxicity - and thus human exposure. The underlying reactions of the indoor air system must be constrained to identify relevant molecular properties to understand the spatial and temporal scales of indoor chemistry and thus predict molecular fate. However, the current research paradigm is observational, with intensive study of single buildings and isolated processes. These studies can only infer fate, not directly track fate. The team will directly measure chemical transformations in the complex indoor multiphase system. Instead of treating buildings as engineered air enclosures, they will be treated as manufactured ecosystems. The team aims to discover the biogeochemical cycles of the indoor environment using stable isotopes to label and track molecules as they move and transform through the many phases of real buildings. This will be the first-time chemists directly track the atoms of oxidants and pollutants through the air and surfaces of an ecosystem - let alone a building. Only with a transformative understanding of the indoor web of biogeochemical processes can pollutant exposure be predicted. This project will help develop predictive capacity for indoor chemistry and open an entirely new avenue to advance environmental and multiphase chemistry.

University of California, Santa Barbara

Santa Barbara, CA

Matthew Fisher, Sagar Vijay, David Weld

\$1,300,000

It has been understood for more than a century that, in quantum mechanics, measurement is special. Measuring a quantum system gives intrinsically random results and irreversibly alters the system itself. Recent theoretical breakthroughs have extended this concept to the many-body regime, demonstrating that simply observing an evolving quantum many-body ensemble can induce new states of matter which cannot arise in

quantum matter. According to this new theoretical viewpoint, all our previous understanding of quantum condensed matter has been restricted to the equilibrium, unmonitored, feedback-free regime; what new phenomena can emerge in quantum many-body systems if future control parameters depend on the results of past observations? This team of PIs from the University of California, Santa Barbara will pursue a joint research program to address these foundational questions and establish the new field of quantum interactive matter.

University of Colorado Boulder

Boulder, CO

Scott Diddams

\$1,000,000

Phased-array astronomical imaging is a technique by which detected electromagnetic (EM) radiation from multiple smaller aperture telescopes is coherently combined to provide images with higher spatial resolution. This approach is widely applied in the microwave and millimeter-wave regions of the spectrum, but progress in phased-array imaging over the largest baselines in the infrared has been limited by the lack of sensitive and broad bandwidth heterodyne detector technology and the means to phase-coherently link these higher frequencies of EM radiation. This project addresses these challenges with a new coherent modality for heterodyne detection of infrared thermal radiation that leverages advances in optical frequency combs emerging from the field of laser physics. The most ambitious implementation, which the PI calls dual-comb electrooptic sampled detection, will use two optical frequency combs to upconvert infrared radiation to the near infrared for detection with mature telecommunications technology. If successful, these advances will enable 10-300× improved spatial resolution; up to 10,000× increase in detected bandwidth; and femtosecond-scale timing resolution intrinsic to the clockwork of the frequency comb itself. Such a novel detector would underpin the scientific foundation of a new generation of infrared phased-array telescopes aimed at answering outstanding questions related to the early lives of stars, galactic and planetary formation, and the origins of the universe and life itself.

cerevisiae: (1) Do natural or engineered mitochondria express bacterial genes? (2) Can mitochondria, which use a non-standard genetic code, be converted to a standard genetic code? (3) Can engineered mitochondria bring bacterial genomes to life? The work will