A nitrogen vacancy (NV) center is a defect in the otherwise uniform crystal-lattice molecular structure of diamond. Researchers have discovered that NV centers can be manipulated at room temperature using pulsed electromagnetic fields, and this suggests a variety of potential applications. For example, NV centers can be made to phosphoresce, which gives rise to the possibility that optical computer data storage may one day be possible on an atomic scale.
An enzyme is a substance produced by a living organism which acts as a catalyst to bring about a specific biochemical reaction. A fuel cell is a device that converts chemical potential energy stored in the fuel’s molecular bonds into electrical energy. Put enzymes and fuel cells together, and you have an enzymatic biofuel cell – a device that uses an enzyme to oxidize – break — the molecular bonds of its fuel, which consists of cheap, plant-based compounds such as sugars and alcohols.
Assistant Professor of Biology

Gordon Berman

Information bottlenecks and the neural control of behavior in fruit flies

“Understanding links between brain and behavior is one of the key questions in neuroscience,” says Gordon Berman, assistant professor of biology and a member of Emory University’s Physics Graduate Program. “In most animals, there exists a limited-capacity transmission channel between the brain and the muscles driving behavior, such as the spinal cord in vertebrates or the ventral nerve cord in insects.”
Assistant Professor of Chemistry

Dennis D. Cao

Cationically Supercharged Electron Acceptors

Organic chemistry deals with the study of carbon-based materials; and, as one of the most plentiful atomic elements in our world, carbon is an inexpensive raw material. Of course there are relatively rare forms of carbon – diamonds, for example — and carbon-incorporating materials created in the lab that are costly, but overall, organic materials are attractive as industrial feedstocks and as the foundation for technological innovation.
Caitlin M. Casey, astronomy, University of Texas at Austin, is taking a new approach to an old problem – in fact, it’s just about the oldest problem in our nearly 14-billion-year-old universe. “The story of our Universe — from the gravitational collapse of matter, to the formation of galaxies, and the physics of the cosmos — has been pieced together using the world’s most powerful telescopes,” Casey points out. “Predominantly, it is stellar light that has given us this story. And yet, stars themselves only shed light on a small fraction of the cosmos.”
Assistant Professor of Chemistry

Jonathan J. Foley, IV

Polaritonic Chemistry with Hybrid Nanoparticles

Nanoparticles that can mediate strong interactions between light and molecules are interesting to scientists because they promise efficient control of chemical reactions for applications like solar-to-chemical energy conversion. Jonathan J. Foley IV, chemistry, William Paterson University, has received a Cottrell Scholar Award from Research Corporation for Science Advancement to evaluate the potential for a novel class of hybrid nanoparticles to serve as a vehicle for facilitating a new regime of strong light-matter interactions, and for opening new opportunities to control chemical reactivity with inexpensive earth-abundant materials.
Assistant Professor of Physics

Benjamin Hunt

Broken Symmetry and Spin-Triplet Pairing in Two-Dimensional Superconductors

Benjamin Hunt, physics, Carnegie Mellon University, has received a Cottrell Scholar Award from Research Corporation for Science Advancement to do work in superconductivity – the movement of electrons without resistance. Specifically, Hunt hopes to provide definitive evidence of spin-triplet superconductivity through experiments sensitive to the spin susceptibility and the symmetry of the Cooper pair wavefunctions. The proposed experiments will be relevant to a larger class of 2D superconductors created from van der Waals layered materials.
So-called “smart materials” can adapt, or be programmed to adapt, to external stimuli such as temperature, moisture, pH, magnetic or electric fields. These materials are created at the molecular level by researchers who are progressively harnessing how molecules interact with one another, not unlike the formation of double helix DNA.
Assistant Professor of Astronomy

Emily Levesque

New Perspectives on Dying Stars

The Large Synoptic Survey Telescope coming online in the early 2020s and the James Webb Space Telescope, scheduled to launch in the spring of 2021, will give astronomers the ability to monitor hundreds of thousands of events in the cosmos on a continuing basis.
Assessing Stellar Feedback in Massive Star-Forming Regions

Stellar feedback, the injection of energy and momentum by stars into the gases and dust clouds of the interstellar medium, plays an important role in how – and how many – new stars are formed in the cosmos. Without stellar feedback, all gas and dust in space would eventually come together through gravitational attraction, forming 10 times too many stars compared what we see today.
Assistant Professor of Chemistry

Ellen M. Matson

**Metal Oxide Clusters as Models for Investigating the Role of Oxygen Vacancies in Small Molecule Activation**

When we finally come up with relatively inexpensive, highly efficient, renewable liquid fuels to power airplanes and heavy equipment, there’s a good chance they will have been engineered on the molecular level. Ellen M. Matson, chemistry, University of Rochester, has received a Cottrell Scholar Award to do fundamental research that may one day allow for the creation of renewable fuels from waste gases such as carbon dioxide and nitrous oxide without a lot of expensive heating and elaborate processing required.
The quest for ever-more efficient catalysts is a major on-going story in the field of chemistry. But the search takes on additional urgency when it comes to finding catalysts that more efficiently aid in the conversion of carbon dioxide to chemical fuels for renewable energy storage and that help remove CO2 from the atmosphere.
Assistant Professor of Physics

Ryan McGorty

**Optical microscopy of sheared phase-separating soft matter systems**

“How can we control and manipulate matter, and what are the mechanisms biological systems use to do so? These questions drive research across many fields, but particularly in the field of soft condensed matter where small perturbations, thermal fluctuations even, can alter structure,” notes Ryan McGorty, assistant professor of physics and biophysics at the University of San Diego.
Assistant Professor of Chemistry

Katherine Mirica

Multifunctional Porous Scaffolds for Monitoring Neurochemicals

Metal Organic Frameworks (MOFs), a class of crystalline materials, are essentially tiny containers made of metal and carbon atoms that can be used for the storage of hydrogen and methane or to capture carbon dioxide, and as frameworks for the construction of molecules that act as catalysts. In the last 10 years researchers have reported more than 20,000 different MOFs arranged into one-, two- and three-dimensional structures. They’re a class of chemical-industrial wonders that are slowly beginning to change our world.
Assistant Professor of Chemistry

Alison Narayan

Biocatalytic reactions for selective, sustainable synthesis

Alison Narayan, chemistry, University of Michigan, has received a Cottrell Scholar Award from Research Corporation for Science Advancement.
Assistant Professor of Physics

Kerstin Perez

Closing in on Sterile Neutrino Dark Matter with NuSTAR

One of the current outer edges of physics, where human knowledge comes up against the unknown, is the question of whether sterile neutrinos actually exist. If they do, the theory goes, these elusive particles interact only with gravity and nothing else described by the Standard Model, although an extension of that model postulates sterile neutrinos may oscillate into the three known “flavors” of neutrinos – electron, muon and tau, which are themselves chargeless and nearly massless.
Assistant Professor of Chemistry  

Paul Raston  

**Laser Spectroscopic Investigation of Atmospherically Important Complexes at Ultra Low Temperature**

Scientists aren’t totally informed about what’s hanging around in earth’s atmosphere – and we’re not talking about UFOs, but something more fundamental. Paul Raston, chemistry & biochemistry, James Madison University, has received a Cottrell Scholar Award from Research Corporation for Science Advancement to explore the subtle interactions between atmospherically important molecules.
Assistant Professor of Astronomy

Emily Rauscher

Exo-Cartography: Resolving Three-Dimensional Images of Extrasolar Worlds

Over the last two decades astronomers have discovered thousands of exoplanets orbiting nearby stars. "We have reached the point where we are no longer just detecting exoplanets, we are measuring properties of their atmospheres, notes Emily Rauscher, astronomy, University of Michigan."
Assistant Professor of Chemistry

Shahir S. Rizk

Reversible self-assembly of bio-responsive nanostructures

Proteins are the workhorses of living cells. And they do their work by folding – assuming intricate shapes to perform precise molecular functions. Shahir S. Rizk, chemistry and biochemistry, Indiana University South Bend, has received a Cottrell Scholar Award from Research Corporation for Science Advancement to figure out a way to use proteins’ folding and conformational talents to engineer artificial nanostructures that can reversibly self-assemble in response to their environments.
Assistant Professor of Physics

Tristan L. Smith

**Fundamental tests of gravity across time, space, and mass**

One of the four fundamental forces of nature, gravity is unique in that it affects all matter and energy and is the weakest force. “This makes gravity both ubiquitous and hard to measure,” notes Tristan L. Smith, physics, Swarthmore College. “Einstein’s theory of general relativity has been extensively tested over decades of research in our solar system, but gravitational effects on galactic and cosmological scales are still largely unknown.”
Assistant Professor of Chemistry

Kana Takematsu

Moving multiple charges with light in derivatized naphthalene photoacids

Understanding and mastering the production and movement of electrical charges is vital to harnessing and improving solar energy technology. In the field of chemistry, the process among atoms and molecules of donating and accepting electrons is called “redox.” Redox reactions are often accompanied by the transfer of positively charged particles called protons, bare hydrogen nuclei devoid of their electrons.
Assistant Professor of Physics

Weichao Tu

Understanding the Rapid Dropout of Killer Electrons in Earth’s Radiation Belt

“Killer electrons” trapped in the Earth’s outer radiation belt are moving at near relativistic speeds and therefore each electron may pack an energy wallop a thousand times more powerful than a medical X-ray. When they attack satellites and other spacecraft, powerful electrical charges build up quickly and must be discharged, sometimes zapping onboard electronics into useless junk.
Small molecule inhibition of formin proteins: specificity and mechanisms of action

Until the 1960s we thought living cells were more or less squishy blobs, like plastic bags filled with liquid- or gel-like cytoplasm. This was due to the limitations of our microscopes. But since then, we’ve learned that cells have exterior and internal support filaments –the microtubule cytoskeleton, and actin, respectively. We’ve also learned that these structures are built and regulated by a class of proteins called formins. During the last decade we’ve used a small organic molecule, called SMIFH2, to inhibit formins from doing their work; it has become a powerful tool for cytoskeleton and actin research. But, ironically, we don’t completely understand how SMIFH2 actually works.
Assistant Professor of Chemistry

Justin J. Wilson

Ligand Design to Sequester Radioactive Strontium, Barium, and Radium

“Under some circumstances, the heavy alkaline earth elements strontium, barium, and radium can act as environmental contaminants that negatively impact human health and industrial processing efforts,” notes Justin J. Wilson, chemistry and chemical biology, Cornell University.