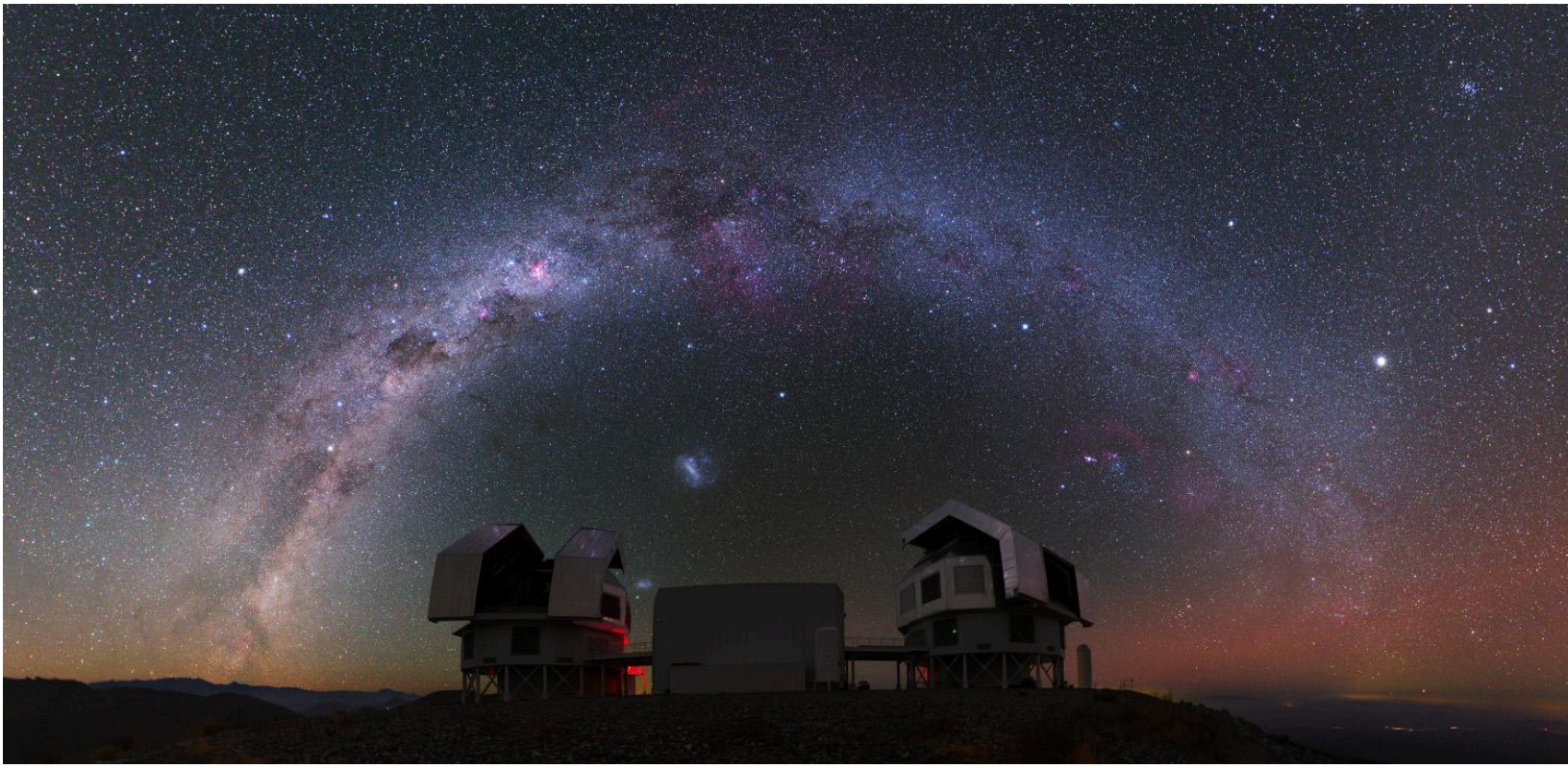
Department of Astronomy and Astrophysics

PhD Program





The Magellan Telescopes at Las Campanas Observatory (credict: Yuri Beletsky)

Big Glass, Big Ideas

The Department of Astronomy & Astrophysics at the University of Chicago offers a diverse and vibrant observational research program with guaranteed access to the Magellan telescopes at Las Campanas Observatory in Chile. Students have the opportunity to participate in a wide array of research projects, using a wide range of observational facilities. Through the Chicago-Carnegie Brinson predoctoral program, a partnership with Carnegie Observatories, students also have the opportunity to spend a year of their PhD studies working alongside the outstanding staff at Carnegie Observatories to expand their horizons. Our grad students enjoy what is among the highest per-capita access to 8-m class telescopes in the country.

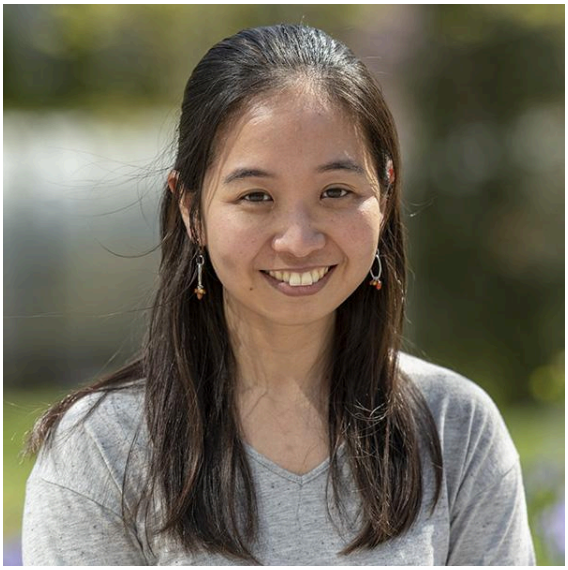
Astronomy and Astrophysics faculty in observations



Jacob Bean

The main theme of Bean's research is the observational study of planets outside the Solar System ("exoplanets"). He uses ground- and space-based telescopes to detect and characterize these worlds. He also builds new instruments as part of the push towards identifying other Earth-like planets.

Chihway Chang



Chang is an observational cosmologist. Her main science interest is to use large optical imaging survey data to study the evolution of the recent Universe through a technique called weak gravitational lensing. She is also interested in combining the rich information from galaxy surveys with that of the cosmic microwave background to study topics of cosmology and astrophysics. She is currently involved in the Dark Energy Survey (DES) and the Rubin Observatory's Legacy Survey of Space and Time (LSST).

Hsiao-Wen Chen



Chen’s research broadly covers issues concerning formation and evolution of galaxies across cosmic time. In particular, she is interested in the properties of diffuse gas in and around galaxies and super massive black holes. The expertise in her group lies in galaxy surveys and absorption-line spectroscopy of distant light sources to study baryon cycles in and out of star-forming regions.



Alex Drlica-Wagner

Drlica-Wagner’s research focuses on using astrophysical observations to understand the fundamental nature of dark matter and dark energy. He works on large cosmic surveys including the Dark Energy Survey (DES) and the Rubin Observatory's Legacy Survey of Space and Time (LSST). Recently, he has been interested in using the faintest and most dark-matter-dominated galaxies to try to understand the fundamental nature of dark matter. He considers himself to be an experimental particle cosmologist, and he is heavily invested in the instruments and infrastructure that make these large surveys possible.

Wendy Freedman



Freedman's research is in observational cosmology (measures of the expansion rate of the universe using the Hubble Space Telescope, Spitzer Space Telescope and the ground-based Magellan telescope). Her current projects involve measurements of the Hubble constant -- the current expansion rate, as well as the past expansion rate, providing constraints on the acceleration of the universe and dark energy. Her other field of interest is the stellar populations of galaxies, the evolution of galaxies, and the initial mass function.



Michael Gladders

Gladders' research centers around the discovery and exploitation of galaxy clusters, and strong gravitational lenses, as cosmological laboratories in which to test ideas of galaxy formation and evolution, and the connection between visible matter and dark matter. He uses ground-based telescopes of various apertures extensively, and all of the major space observatories, working from radio to X-ray wavelengths as needed by various studies.



Alexander Ji

Ji's research focuses on observing and interpreting the chemical content of stars in surviving relics of the first galaxies, the so-called "ultra-faint" dwarf galaxies. He studies nearby stars and galaxies to understand the first stars and galaxies, the origin of the elements, the history of our galaxy, and the nature of dark matter.



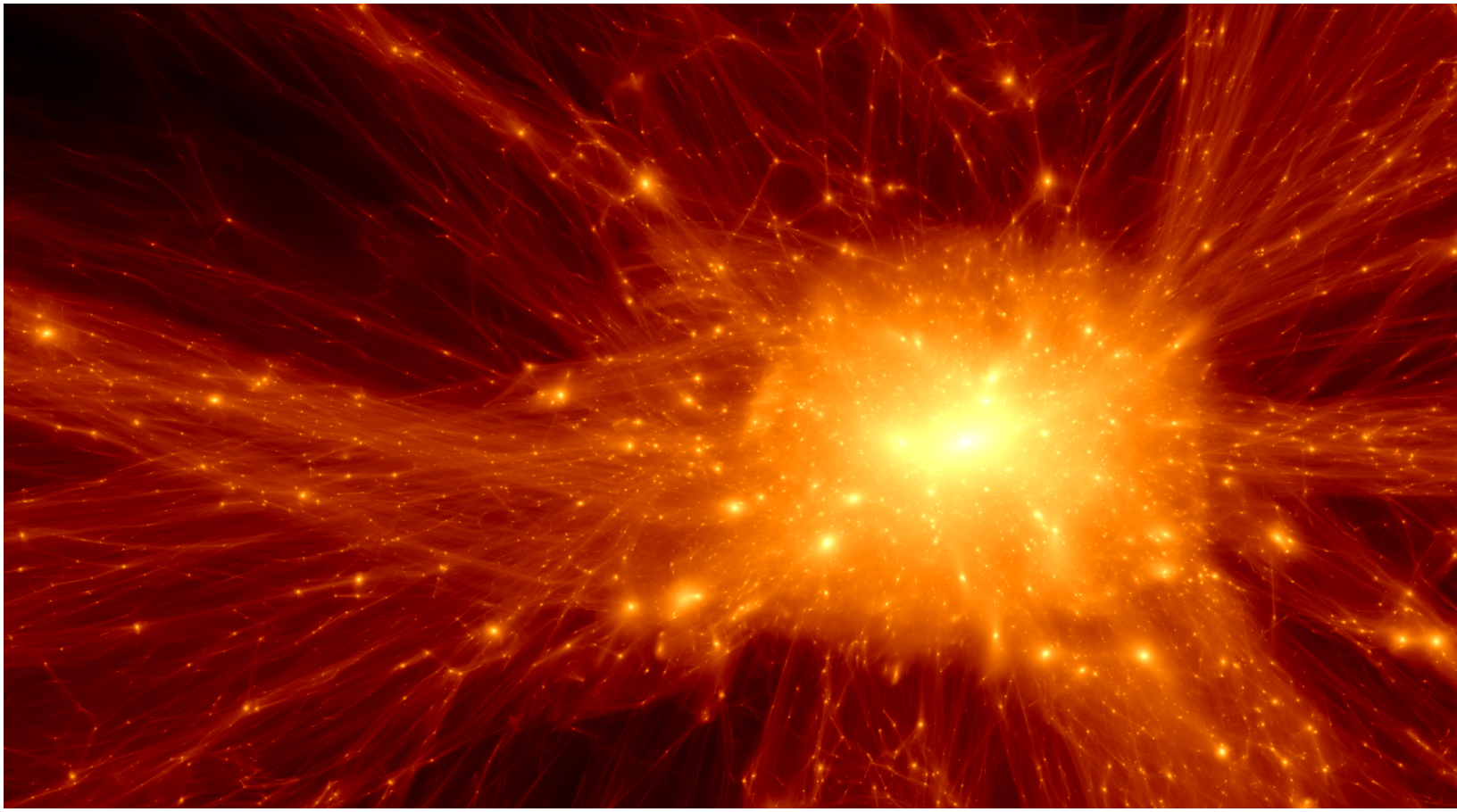
Richard Kron

Kron's interests include using large sky surveys to constrain how the populations of galaxies and quasars were built up, and how they have evolved with cosmic time.

Irina Zhuravleva



Zhuravleva's primary research interests are high-energy X-ray astrophysics and the physics of galaxy clusters. Using X-ray imaging and spectroscopic data and the computational modeling of relevant astrophysical processes, she studies the interactions between supermassive black holes and their host galaxies, processes that shape the large-scale evolution of galaxy clusters, and fundamental microscopic properties of intergalactic plasmas. She is involved in the development of the next X-ray telescope, XRISM, that will observe the X-ray Universe with unprecedented spectral resolution.

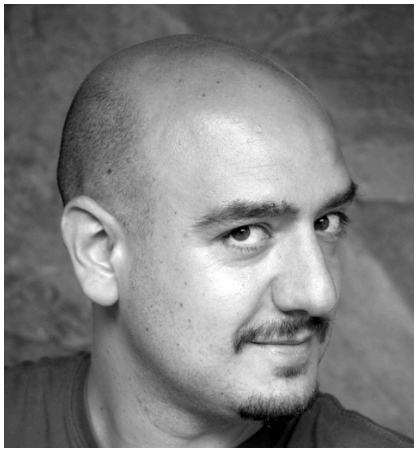


Splashback surface around cluster-sized halo *(credict: Diemer & Mansfield)*

Putting the Physics in Astrophysics

The Department of Astronomy and Astrophysics is the home of world-leaders in cosmological physics, astroparticle and high-energy physics, plasma physics and astrophysics, and solar system astronomy and astrophysics, particularly in the areas of early universe physics, high-resolution galaxy formation modeling and modeling of reionization and the intergalactic medium in the early universe. High-performance computing is the workhorse of astrophysical research across all of our science themes. We have access to computational facilities through the Research Computing Center at the University and through connections to Argonne National Laboratory and Fermilab.

Astronomy and Astrophysics faculty in theory



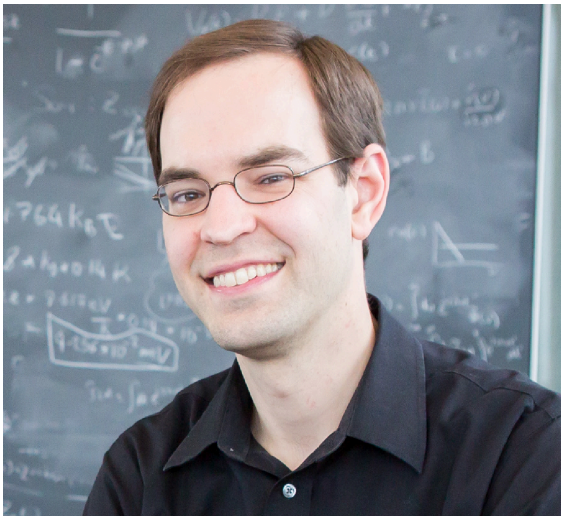
Damiano Caprioli

Caprioli's research involves high-energy astrophysical phenomena and, in particular, the non-thermal nature of astrophysical plasmas. He uses both analytical and numerical (particle-in-cells simulations) to study how particles can be accelerated to the highest energies in the universe. Such physical mechanisms are at the core of the most violent phenomena in the universe, such as stellar explosions (supernovae, kilonovae, gamma-ray bursts), supernova remnants, active galactic nuclei and their jets, pulsars, and more. He is also interested in other ways of testing particle acceleration in laboratory plasma experiments and through in-situ measurements in the heliosphere, and in the role of non-thermal particles and magnetic fields in galaxy evolution.



Fausto Cattaneo

Cattaneo's interests lie in the computational modeling of basic astrophysical processes like the generation of magnetic fields, the transport of angular momentum in accretion discs, or the transport of energy by turbulent convection.



Daniel Fabrycky

Fabrycky studies the dynamics of extrasolar planets. Over the past two decades, discoveries of planets orbiting other stars have poured in from a variety of different detection techniques, and the resulting menagerie of planetary types and system architectures poses many theoretical issues. Fabrycky studies how the observations constrain the configurations of these exoplanetary systems, as well as how gravitational interactions, tidal effects, and energy dissipation shape them.



Scott Dodelson

Dodelson's primary research interest is in fundamental physics involving new pieces concerning dark matter, dark energy, and inflation. The goal of cosmology over the coming decades is to either learn about new physics or replace the current model. What is dark matter? Is the dark energy vacuum energy? If so, why does it have such a peculiar value? Did inflation really happen? If so, is there any way to relate the fields that drove inflation to those we know about today?



Nickolay Y. Gnedin

Gnedin's research interests range from General Relativity to physics of the interstellar medium to cosmology. He works on numerical cosmological simulations, including (but not limited to) simulating galaxy formation and evolution of the intergalactic medium.



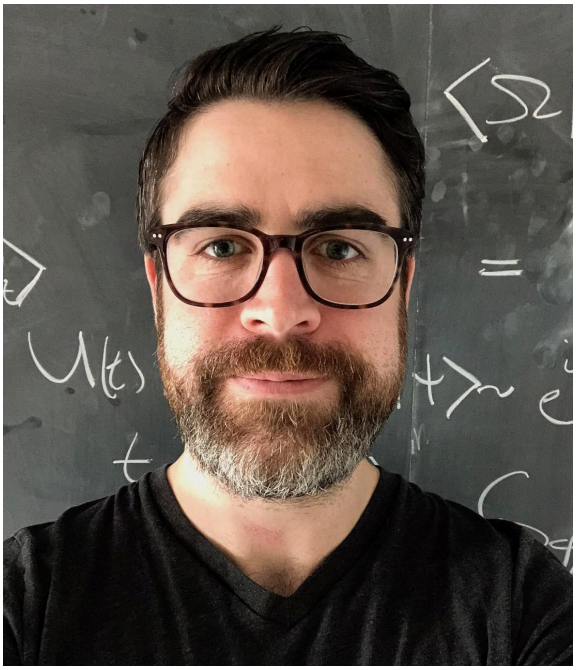
Daniel E. Holz

Holz's research focuses on gravitational waves. He is particularly interested in what we can learn about physics, astronomy, and cosmology from our detections of gravitational wave sources. He is a member of LIGO.



Wayne Hu

Hu's research focuses on the theory and phenomenology of structure formation in the Universe as revealed in Cosmic Microwave Background anisotropies, gravitational lensing, galaxy clustering and galaxy clusters.



Austin Joyce

Joyce is a theorist with broad interests at the interface between cosmology, high energy physics, and gravity. A primary focus is on the interplay between cosmology and fundamental physics, and how we can use each to learn about the other. He applies effective field theory techniques to gravitational and cosmological questions in order to study the nature of dark energy/dark matter, and to probe the physics of the very early Universe. He also maintains interests in more theoretical questions involving gravity and quantum field theory in a variety of settings.



Harley Katz

Katz’s research focuses on the formation of the first generations of stars, galaxies, and black holes in the early Universe. He is particularly interested in combining cosmological simulations with observations from state-of-the-art telescopes (JWST, Hubble, ALMA, etc.) to elucidate the physics that drives galaxy formation at different cosmic epochs.



Eliza Kempton

Kempton's research focuses on the atmospheres of extrasolar planets. She is a theorist who uses a range of modeling approaches combined with observational data as a means of probing the chemistry, thermal structures, and dynamics of exoplanet atmospheres. She is motivated by questions relating to the diversity of exoplanets that populate our galaxy and how that informs our understanding of our own solar system, as well as planet formation and evolution more broadly.



Edward “Rocky” W. Kolb

Kolb's research focuses on theoretical early-universe cosmology involving astrophysics, particle physics, and general relativity. Gravitational particle production during the inflationary era, the origin of the baryon asymmetry, reheating the universe after inflation, and cosmological phase transitions are some of the areas of research.



Andrey V. Kravtsov

Kravtsov's research focuses on modelling galaxy formation in cosmological context. His recent research in particular has aimed to understand the processes of star formation and stellar feedback and their effects on galaxy evolution. He also studies properties of dark matter halos, clustering of halos, and galaxy-halo connection.

Gordon Krnjaic



Krnjaic's research focuses on theoretical particle physics and cosmology beyond the standard model. Recently he has developed new experiments and search strategies to discover dark matter and hidden forces in non-traditional settings including electron beam dump fixed-target experiments and neutrino factories. He also builds models of new physics at the electroweak-scale motivated both by naturalness and upcoming searches at the Large Hadron Collider.



Jamie A.P. Law-Smith

Law-Smith is interested in a variety of problems in theoretical astrophysics and theoretical physics, including tidal disruptions of stars by black holes, the formation of gravitational wave sources, the structure of active galactic nucleus disks with embedded stars, the host galaxies of high energy astrophysical phenomena, black holes and de Sitter matrix theory, vacuum decay, and de Sitter space in string theory.

Diana K. Powell



Powell studies the nature of extrasolar planets, how they form, and how they evolve. Her work spans a variety of topics, including protoplanetary disks, planet formation, and planetary atmospheres. She is particularly interested in using the detailed evolution of small particles to interpret observational data and understand planetary evolution.



Leslie Rogers

Rogers studies the formation, interior structure, and evolution of exoplanets. Her research aims to deepen the current understanding of the rich physics governing sub-Neptune-size planet interiors, to discover bulk composition trends in the growing census of known exoplanets, and to connect these composition trends back to distinct planet formation pathways. To pursue these goals, Rogers and her group advance numerical models for the interior, evolution, and formation of small exoplanets, and develop statistical frameworks to connect theory and observations.



Robert Rosner

Rosner studies astrophysical fluid dynamics and plasma physics problems. Much of his work involves developing new numerical simulation tools for modeling astrophysical phenomena, as well as validating these simulations using terrestrial laboratory experiments.



The South Pole Telescope *(credict: Jeff McMahon)*

Cutting Edge Detectors and Instrumentation Development

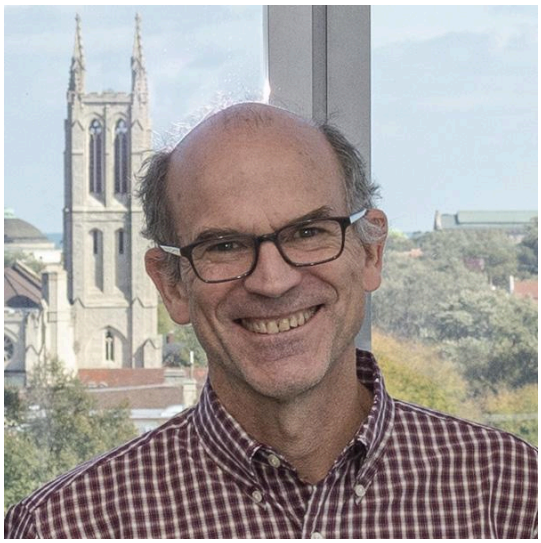
Detectors and instrumentation are critical for astronomy and astrophysics. Innovation and development of detector technology enables us to push measurements to higher precision and leads to new, cutting-edge experiments. The Department of Astronomy and Astrophysics has a history of building instrumentation, from cosmic microwave background and cosmic-ray experiments to optical and infrared instrumentation, with many scientific opportunities for developing new detectors and advanced instrumentation through our partners in the Institute for Molecular Engineering Pritzker Nanofabrication Facility, Argonne National Laboratory and Fermilab.

Astronomy and Astrophysics faculty in experiment



Bradford Benson

Benson is an experimental cosmologist, who uses measurements of the cosmic microwave background (CMB) and clusters of galaxies to constrain the physics of the Big Bang, dark energy, and neutrinos. He works on mm-wavelength detectors and instrumentation, and has had a leading role in the development of multiple cameras for the South Pole Telescope (SPT). He is working on the development of the next-generation CMB-S4 project, expected to improve CMB-based constraints by over an order of magnitude.



John Carlstrom

Carlstrom is the director of the South Pole Telescope (SPT) project, which probes inflation, enables precision measurements of cosmological parameters and investigations of extensions to the standard model, such as the number and masses of the neutrinos, and the nature of dark energy. SPT enables direct detections of the emergence and evolution of structure in the universe through the small-angular-scale distortions they impart on the background, such as gravitational lensing from the mass in the universe and the scattering from ionized gas (the SZ effects).



Clarence Chang

Chang's interests focus on observational cosmology with a particular emphasis on developing new superconducting technology for use in new experiments. He is part of a joint Chicago/Argonne superconducting detector development collaboration which developed and built the focal plane for the SPT-3G experiment. This focal plane, with over 15,000 polarization sensitive detectors, will enable the South Pole Telescope to observe 2500 square degrees with unprecedented sensitivity.



Jeffrey McMahon

McMahon is an experimentalist who studies cosmology and fundamental physics through measurements of the cosmic microwave background (CMB). CMB signals, including its polarization, gravitational lensing, and small scale secondary anisotropies, have yet to be fully exploited. Measurement of the spatial pattern of CMB polarization will constrain the energy scale of inflation. Measurement of CMB lensing will provide a tight constraint on the sum of the neutrino masses and through cross-correlations with external data sets will provide a measurement of astrophysical bias. He works with the Atacama Cosmology Telescope and Simons Observatory.



Paolo Privitera

As an experimental particle physicist at CERN, Privitera measured the properties of fundamental particles as the Z and W bosons, the lepton and the b quark. Privitera's group went on to study ultra-high energy cosmic rays (UHECRs) with the Pierre Auger Observatory. Current efforts include the development of compact Fluorescence Detectors and measurements of UHECRs composition and anisotropy. He is also leading DAMIC-M, an experiment for direct detection of dark matter based on advanced CCD technology.



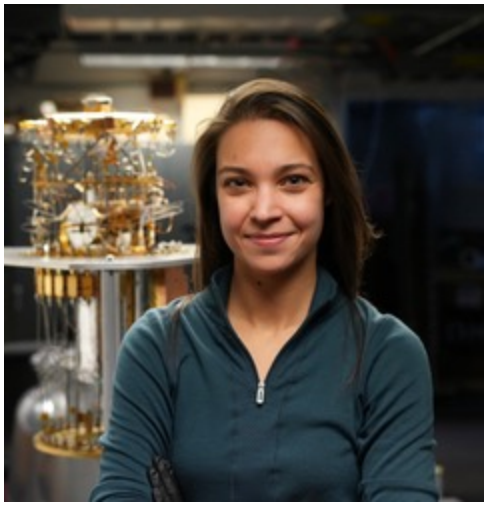
Juan Estrada

Estrada develops novel applications for CCD technology that probes wide-ranging areas of particle physics, including cosmology, dark matter, neutrino detection, and quantum imaging.



Abigail Vieregg

Vieregg builds radio and millimeter wave experiments and uses them for neutrino astrophysics and cosmology with the cosmic microwave background. She currently leads hardware development and analysis efforts on ARA and ANITA, which use the Antarctic ice as a target for the highest energy cosmic neutrinos. Vieregg is the PI of PUEO and RNO, next-generation balloon-borne and ground-based radio detectors for ultra-high energy neutrinos. She is also involved in CMB-S4, a future ground-based cosmic microwave background experiment, serving as the technical coordinator and on the executive team.



Jessica Zebrowski

Zebrowski's research centers on understanding cosmic acceleration. She is interested in developing mm-wave instrumentation and data analysis techniques to build pioneering line intensity mapping experiments. These experiments will constrain cosmology by mapping the evolution of large-scale structure over time. She is working with a small team to design and integrate SPT-SLIM, a pathfinder mm-wave line intensity mapping experiment with the potential for a first detection of the CO power spectrum.