UC Davis Physics Graduate Program Research Areas– 2020

Cosmology and Astrophysics

The UCD cosmology group is pursuing key investigations of the evolution of the universe from the inflation era to the first stars and galaxies. Cosmology has become a driver at several exciting frontiers of fundamental physics. The mystery of the dark matter that dominates the mass of the universe is one of these. More intriguing, the mysterious dark energy that fills the universe could drive a revolution in fundamental physics. Breakthroughs in both theory and observation are behind our move toward ever higher precision. In experiments planned by our group, percent level precision will be reached on dark energy parameters which today are known to only a factor of two, and with new theoretical advances we will address the underlying physics. Areas of specialty cover the physics of early universe cosmology, dark matter, dark energy, high-precision cosmological phenomenology, gravitational lensing, quasars and high-redshift galaxies and clusters.

Cosmology Faculty and Research Interests:

[Number after name is office # in Physics Building]

Albrecht	429	Theory of the early universe, inflation
*Becker	513	Observational astronomy, quasars
Boeshaar	233	Observation of extreme low mass stars
Bradac	531	Observational cosmology, weak gravitational lensing with clusters of galaxies
Fassnacht	515	Observational cosmology, strong lensing
Jones	513	Observations of distant galaxies collected with large telescopes
Kaloper	509	Theory of the early universe
Knox	505	Theory and phenomenology of cosmological observables
Lubin	507	Observational astronomy, distant clusters
Tyson	514B	Experimental cosmology, gravitational lensing
Valenti	511	Stellar Evolution and Supernovae, Surveys and time domain phenomena
		Cosmology, AGN reverberation mapping, Spectroscopic and Photometric data analysis
Wittman	529	Observational cosmology, weak gravitational lensing

Fields, Strings, and Gravity

The UC Davis Fields, Strings, and Gravity group studies foundational questions in theoretical physics and associated mathematics. We are interested in understanding how the universe works at its most fundamental level. Some of the questions we explore involve elucidating the structure of spacetime and its potential emergence from some deeper underlying description, unearthing the crucial features of quantum field theories, and exploring which aspects of the quantum world manifest themselves at macroscopic scales.

Fields, Strings, and Gravity Faculty and Research Interests:

[Number after name is office # in Physics Building]

Hubeny	String theory, general relativity, gauge/gravity duality
Rangamani	String theory, quantum field theory, quantum gravity
Trnka	Quantum field theory, scattering amplitudes

Additional faculty members in other departments on campus:

Tudor Dimofte

Andrew Waldron

High Energy Theory

The UC Davis high energy theory group conducts a wide range of research topics aimed at understanding the most fundamental building blocks of nature and their interactions. The group has strong efforts in collider phenomenology and in physics beyond the standard model, including supersymmetry, extra dimensions, and strong dynamics.

High Energy Theory Faculty and Research Interests:

[Number after name is office # in Physics Building]

Cheng	433	Physics beyond the Standard Model; supersymmetry; extra dimensions
Kiskis*	443	Quantum chromodynamics; lattice gauge theory
Luty	431	Physics beyond the Standard Model; supersymmetry; extra dimensions
Terning	435	Physics beyond the Standard Model; supersymmetry; extra dimensions
Carlip	437	Quantum gravity; black holes; and general relativity

High Energy Experiment

High energy experimental physics employs a broad range of experiments to study the tiniest objects in the universe, the fundamental building blocks of matter, and their interactions with each other. These include sub-nucleonic particles such as quarks, fundamental leptons such as taus and neutrinos, and massive bosons such as W, Z and the Higgs. Search for exotic new objects such as dark matter, monopoles, supersymmetric partners, and massive new quarks and bosons complete the spectrum of experimental activity. At the CMS experiment at the Large Hadron Collider in Geneva, Switzerland, we record and analyze the world's highest energy proton-proton collisions with the goal of a better understanding of elementary particles and forces, and discovering possible new particles and interactions. Our work at deep underground laboratories involves detecting rare processes. SNO+ is searching for neutrinoless double-beta decay at SNOLab in Canada. We are involved in two experiments sensitive to dark matter scattering: the LUX detector at the Sanford lab in South Dakota and DarkSide at the Gran Sasso lab in Italy. Besides operating and analyzing various experiments, we are deeply involved in technical R&D aimed at various future projects: upgrade of the CMS experiment, ANNIE at Fermilab and protoDUNE at CERN aimed at developing future large neutrino detectors, and the next generation dark matter experiment called LZ.

High Energy Experiment Faculty and Research Interests:

[Number after name is office # in Physics Building]

Chertok	329	Supersymmetry searches involving lepton signatures, particle detector readout. Detectors future linear collider.
Conway	311	Higgs boson, dark matter, and other new particle searches, and pixel tracking detector work in the CMS experiment at the Large Hadron Collider at CERN.
Erbacher	343	Properties of the top quark and searches for new physics using high energy electrons and muons. Particle detector triggers and readout technology.
Lander*	319	Detector development for particle physics.
Mulhearn	317	Studies interactions of matter at small length scales, using the highest energy probe availab as a collaborator on the CMS experiment at LHC
Pantic	327	Direct detection of dark matter
Pellett*	378	CMS experiment at LHC; also R&D for future linear collider.
Prebys	337	High Energy Particle Physics, Accelerator Physics, Mu2e experiment at Fermilab
Svoboda	349	Neutrino physics, searches for dark matter particles, nuclear non-proliferation
Tripathi	313	Searches for Technicolor at LHC, Gamma-ray Astrophysics, Development of readout photon sensors. Direct searches for dark matter.

Condensed Matter Experiment

Condensed matter physics studies the properties of materials, including novel materials, surfaces, complex systems, nanoscience, quantum technologies, and biological physics. These include synthesis of strongly correlated and magnetic materials, such as heavy fermion materials, high T_c superconductors, colossal magnetoresistive materials, and half-metals. Other areas of study here at UCD are surface and interface physics, spintronics and magnetism at the nanoscale, topological insulators, low temperature physics (superconductors, superfluid helium, magnetic materials), and imaging and characterization of biological molecules.

Condensed Matter Experiment Faculty and Research Interests:

[Number after name is office # in Physics Building unless indicated otherwise]

Chiang	235	Imaging molecules and chemical reactions by scanning tunneling microscopy. Phase transition on surfaces using low energy electron microscopy.
Coleman*	2101 MSB	Far infrared spectroscopy and phase transitions in solids.
Corruccini*	205	Low temperature magnetism of dipolar and/or frustrated systems.
Curro	201	Nuclear Magnetic Resonance (NMR) of novel condensed matter systems. ODMR NV centers in diamond
Radulaski	3179 Kemper	Nanophotonics, quantum communication and computation, integrated quantum opti systems

Taufour	217	New materials with novel physical properties
Vishik	239	Spectroscopies of advanced materials
Yu	203	Synthesis and characterization of colloidal nanocrystals, including measurements of th optical, electrical, and low temperature transport properties.
Zhu	237	Studies of materials, surfaces, and biomolecules using nonlinear light scattering a ellipsometry methods.
Zieve	243	Low temperature physics (quantum critical behavior, superfluid helium vortices), granular matter.

Additional faculty members in other departments on campus:

Jeremy Munday

Condensed Matter Theory

Condensed matter theory is concerned with explaining and predicting the properties of solids. Its excitement stems from the many fascinating and unexpected behaviors which collections of interacting nuclei and electrons can exhibit: from quantum phase transitions, half-metalism, and high temperature superconductivity, to the quantum Hall effect, Bose-Einstein condensation, and magnetism in nanostructures. At the same time, research in condensed matter theory has a practical motivation in designing new materials (colossal magnetoresistors, spin valves, novel superconductors) which are the future of new technologies. The condensed matter theory group at Davis conducts research in all the above areas, and has a high level of funding for students and post-docs from the National Science Foundation, the Department of Energy, and Los Alamos and Lawrence Livermore National Laboratories. It has close connections with the Computational Science and Engineering Center at UC Davis. Students in condensed matter theory learn and use modern techniques of quantum field theory, classical and quantum simulations, and correlated band theory to conduct their research. Condensed matter theory also has close connections with theoretical biological physics, as the functionality of biological molecules, and their interactions with each other, are determined by the same sorts of magnetic and electronic considerations as for solids. The condensed matter theory group has active efforts in problems like protein aggregation, protein-membrane interactions, and regulation networks.

Condensed Matter Theory Faculty and Research Interests:

[Number after name is office # in Physics Building]

Cox	407	Theoretical biological physics (protein aggregation, protein-membrane interactions, electro and magnetic properties of biomolecules), strongly correlated electronic materials
Fong*	403	Electronic structure theory of spintronic materials and biomolecules
Goldman		Computational Neuroscience
Klein*	415	Electronic structure theory of novel materials
Pickett	427	Electronic structure of novel superconductors, magnets, and nanostructured materials
Savrasov	417	Theoretical condensed matter, electronic structure of solids, computational approaches

Scalettar	409	Quantum Monte Carlo simulations of interacting quantum solids and liquids, magnetism and superconductivity
Singh	425	Frustrated Magnetism, Quantum spin-liquid phases of matter
Zimanyi	405	Disordered, interacting classical and quantum systems; magnetic hysteresis; solar ener optimization

Complexity

Contemporary science and engineering confront problems at unprecedented levels of complexity and difficulty that transcend traditional mathematical and statistical methods. Progress in exploring and analyzing the large-scale, complex systems of current interest requires new computational tools and concepts. The discipline of Computational Complex Systems has emerged to directly address these challenges. As a response to these trends, Computational Complex Systems is focusing its education and research activities on the uses of computational methods and the development of information-processing concepts as powerful tools for discovery, understanding, and design of complex multiscale systems and their related mathematical structures. Computational facilities include a 700+ CPU Linux cluster, a 57,344 CPU massively parallel logic multiprocessor, several Cellular Automata Machines (CAM-8s), and the KeckCAVES immersive visualization facility (keckcaves.org).

Faculty and Research Interests:

[Number after name is office # in Physics Building unless indicated otherwise]

Crutchfield	197	Patterns---what they are and how nature generates them---and how we discover n ones. Current research centers on computational mechanics, thephysics of informati statistical inference for nonlinear processes, genetic algorithms, evolutionary theo machine learning, and distributed robotics.
Rundle	534B	Research focused on pattern analysis of complex systems; understanding the dynam of earthquakes through numerical simulations; the dynamics of driven nonlinear Ea systems; and adaptation in general complex systems.
D'Souza	3057 Kemper	Complex networks, percolation, cascades, interdependent complex systems

Additional faculty members in other departments on campus:

Jean-Pierre Delplanque (Mechanical & Aeronautical Engineering)

Roland Freund (Mathematics)

Nuclear Physics

Modern nuclear physics pushes our limits of what might be considered Nuclear matter. Relativistic heavy ion physics uses the tools of high energy physics to study the hot dense systems created in collisions of gold nuclei at close to the speed of light. These collisions create temperatures and densities that far exceed those that are reached in the cores of stars. Matter at such extremes existed in the early phases of the big bang and may still exist in the cores of neutron stars or other astrophysical objects. Indeed similar physics can be done by studying the emissions of energetic particles and gamma-rays from such objects. Experiments with collisions of heavy ions at the largest available energies are useful to study the properties of the main constituents of nuclear matter (quarks and gluons, the particles that carry the strong nuclear force) at these large energy densities. The matter produced in the collisions no longer behaves like normal nuclear matter, instead it behaves surprisingly like a liquid, but one whose constituents are quarks and gluons.

Nuclear Faculty and Research Interests:

[Number after name is office # in Physics Building]

Calderon	397A	Heavy quark production in relativistic heavy ion collisions
Cebra	387A	The behavior of the hot dense nuclear matter created in relativistic heavy ion collisions.
Ferenc	540	Development of improved photodetectors and challenging experiments in which light collection is critical. Cosmic gamma-rays.
Vogt	533	Phenomenology. Quantum chromodynamics. Heavy quark contributions in nucleons and nuclei.

Physics Education

The Physics Education Research Group is an active and diverse group of individuals working together to better understand a variety of issues related to the learning and teaching of physics. Graduate students in the group come from both physics and science education. Four graduate students have gotten their Physics PhD's in the past three years and there are currently two graduate students from the Physics Department in the group. Previous grad students' research focus has been on i) gaining a better understanding of instructor behaviors and the resulting effects on student learning, ii) studies of intrinsic motivation and self-efficacy, iii) linguistic analysis of student's discussions with their peers and ways to elevate those scientific discussions, and iv) results of taking introductory physics early in a student's academic career (i.e. at the same time as calculus but before introductory chemistry). Current grad students are interested in issues of social groups who are underrepresented in physics and also in the effects of psychological issues (such as anxiety) on academic performance. A wide range of both qualitative and quantitative research methods are used by the group. There are currently two faculty (David Webb and Wendell Potter) leading the group and also ongoing connections with faculty members Tobin White and Cindy Passmore from the School of Education.

Physics Education Faculty and Research Interests:

[Number after name is office # Physics Building]

*Webb	209	Physics learning and effective curriculum and teaching approaches.

* denotes Emeritus