Dark Universe Science Center

Our universe is driven by unseen forces. From the development of galaxies to the expansion of space itself, the evolution of our cosmos has been driven by the invisible content of the universe. Determining the nature of the dark universe and how it controlled the formation of galaxies is one of the great science questions of our time.

The University of Washington Dark Universe Science Center brings experts in dark matter, dark energy, and gravity together with experts in how the invisible universe drives the formation and development of the stars and galaxies we see. By combining observations of how stars and galaxies develop with direct measurements of the universe's invisible content, we hope to fundamentally change our understanding of the dark universe.

DUSC is currently being formed and our goal is to develop a major center for interdisciplinary research on the dark universe, with theorists and experimentalists working together to exploit the many resources available at UW. These include: close connections with UW Physics and Astronomy departments, the Institute for Nuclear Theory with its many visitors and workshops, CENPA, and many other well known groups in theoretical and experimental physics. DUSC members plan to prepare a proposal for major research-center funding in 2015. A faculty search is currently under way, and our new colleagues will help determine the specific aims of our proposal.

The core science areas of DUSC are:

**Dark Matter**

Leslie Rosenberg, Gray Rybka and Alvaro Chavarria aim to understand the particle nature of the universe's dark matter. Dark matter drives the formation of galaxies, and its gravitational influence is seen from the Cosmic Microwave Background (CMB) in the early universe to the rotation of our Milky Way today. The two theoretically favored dark matter particle candidates are axions and WIMPs. Rosenberg and Rybka are the PI and co-spokesperson of the Axion Dark Matter eXperiment (ADMX) located here at the University of Washington. Chavarria searches for light WIMPs with the DAMIC detector, a CCD array deployed deep underground.

**Dark Energy**
The University of Washington is helping lead the construction of the Large Synoptic Survey Telescope (LSST) that will make precision measurements of dark energy and dark matter through a survey of 20 billion stars and galaxies. Željko Ivezić is the LSST Project Scientist, and Andy Becker, Andy Connolly and Mario Juric are helping lead the development of the LSST analysis pipeline. The UW LSST group also includes research scientists Daniels, Jones, Krughoff, Owen, and Yoachim, and several graduate and undergraduate students. LSST was identified by the Astronomy and Astrophysics 2010 Decadal Survey as the highest US priority for cosmological measurements of dark energy and dark matter.

Galaxy Evolution and Dynamics

Miguel Morales and Julianne Dalcanton use the origin and evolution of galaxies to probe the fundamental physics of the dark universe. Morales helped create the new field of 21 cm cosmology and leads the international effort to observe the first stars and galaxies with the Murchison Widefield Array (MWA) in Australia. This new technique can trace the formation of galaxies across cosmic time—from the Epoch of Reionization when dark matter drove the formation of the first stars to more recent times when dark energy starts to drive galaxies apart and impede the formation of clusters. Dalcanton uses extensive Hubble Space Telescope observations (e.g. PHAT) of the structure and kinematics of nearby galaxies to constrain models of dark matter and galaxy formation.

Gravity

The Eöt-Wash group is one of the highest profile physics programs at the University of Washington, and includes Eric Adelberger (National Academy), Blayne Heckel, Jens Gundlach, and Svenja Fleischer. It is through gravity that dark matter and dark energy drive the evolution of our cosmos, and in some theories dark matter or dark energy are replaced by modifications of Einstein's gravity. The Eöt-Wash group has produced the most stringent tests of Einstein's gravity, tightly constraining extra dimensions and experimentally demonstrating the equivalence principle. Any deviations from Einstein's gravity would revolutionize our understanding of the dark universe.

Astroparticle Physics
Jason Detwiler works on the Majorana experiment. In searching for neutrinoless double-beta decay, it is expected to achieve an unprecedented combination of energy threshold, backgrounds, and exposure to perform sensitive searches for low-mass WIMPs, solar axions, axion-like dark matter, supernova neutrinos, and other astrophysical phenomena.

Jason has also worked on the KamLAND and SNO experiments and co-authored papers on solar neutrino observations, supernova neutrino signals, and searches for neutrino signals coincident with gamma ray bursts. Jeffrey Wilkes and Toby Burnett concentrate on the connections between particle physics and astrophysics. Wilkes is a member of the Super-Kamiokande and T2K neutrino experiments. He and Burnett led the WALTA cosmic ray / high school outreach project for many years. Burnett is a major player in the analysis of Fermi gamma-ray data with interests in precision data analysis and using the high energy sky to improve our understanding of extreme astrophysics phenomena.

**Theory**

The Dark Universe Science Center has a strong tradition of individual contributions in theory. Ann Nelson, James Bardeen, and David Kaplan are members of the National Academy of Science, and are internationally recognized for their theoretical contributions to early universe physics and cosmology. Matt McQuinn is the newest member of the center, and studies the formation and evolution of cosmic structure. He has made key predictions for 21 cm Cosmology and upcoming observations with both optical and radio telescopes. Sanjay Reddy works on nuclear and neutrino astrophysics and has an interested in constraining fundamental physics using observations of neutron stars and supernova. Tom Quinn leads the UW N-body shop, which is internationally recognized for their theoretical work on how dark matter drives the formation and dynamics of galaxies.

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