Project: Telescope Optics and Instrumentation for measuring the Cosmic Microwave Background

Our research focuses on developing new instrumentation to study the formation and evolution of the universe through precision measurements of microwave radiation. Past measurements of the cosmic microwave background (CMB) provided an exquisite picture of the early universe, which combined with astronomical observations at other wavelengths led to strong evidence that we live in a dark energy and dark matter dominated universe; however, we still do not fully understand fundamental aspects of the universe. What are dark energy and dark matter? Did inflation occur in the early universe, and can we understand it? How did the primordial fluctuations evolve into galaxies, stars, and planets? What physical models best describe the past, present, and future of the cosmos?

The instruments we develop help address aspects of these questions through more sensitive observations at millimeter and sub-millimeter wavelengths. We survey the CMB temperature and polarization in unprecedented detail, enabling a wide range of science objectives, including: new constraints on the physics of inflation, new probes of dark energy and modified gravity, characterization of the dark matter distribution, measurements of the neutrino mass sum, and the discovery of both galaxy clusters and high-redshift galaxies.

In 2008 observations began with the six-meter Atacama Cosmology Telescope, located at 5190 meters elevation in the Chilean desert. The ACT data has led to a variety of results, including first detections of the power spectrum of CMB gravitational lensing as well as the kinematic Sunyaev-Zel'dovich effect. We are now working on ACTPol – the first polarization sensitive receiver for ACT - and the Advanced ACTPol upgrade. We are working on characterizing the instrument, running observations, developing detectors and instrumentation for the Advanced ACTPol upgrade, and analyzing ACTPol data, including cross-correlating the data with measurements from other observatories that span the electromagnetic spectrum. We are also collaborating on the upcoming Simons Observatory and CCAT-prime projects to measure the CMB with far better sensitivity than the ACT.

Summer researchers with our group work on projects related to studying aspects of the telescope optics, 3D printing telescope designs, working with graduate students on testing detectors and optical materials in our laboratory, and designing new hardware for the laboratory that we use to study the telescope optics and instrumentation. More information about our projects can be found on the group website at: https://www.classe.cornell.edu/~mdn49/