



College of Natural Sciences & Mathematics

UNIVERSITY OF DENVER

Physics & Astronomy Colloquium

October 2nd, 12.00 pm, ECS 301



Charlotte Snow

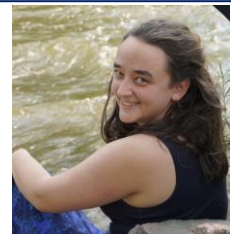
Physics & Astronomy Undergraduate Researcher

Connecting Cosmology to Optics: Investigating Cosmological Perturbation Dynamics Through Optical Analogs

The Mukhanov-Sasaki (MS) equation governs the evolution of primordial scalar perturbations during inflation, encoding the quantum-to-classical transition responsible for the large-scale structure of the universe. We present a formally exact optical analogue of the MS equation in the de Sitter limit, realized through a gradient-index (GRIN) medium whose refractive index profile $n(z)$ is derived directly from matching the paraxial beam equation's oscillator frequency to that of the MS equation. The comoving wavenumber k emerges from this matching as $k = k_{\perp}^2/2k_0$ - the natural phase-accumulation rate of a paraxial mode - establishing a rigorous, non-arbitrary correspondence between beam envelope dynamics and inflationary mode evolution, rather than a qualitative resemblance. The resulting profile requires $n(z)$ to diverge at the horizon ($z \rightarrow z^*$) while approaching the background value far from it, mapping cosmological horizon crossing onto the transition of the optical refractive index. Numerically integrating the optical equation from Bunch-Davies-type initial conditions reproduces the exact closed-form analytic solution to high precision (better than one part in 10^8) across the full domain, including horizon crossing, and correctly recovers the frozen value of the curvature-perturbation analogue $|z\Psi(z)|$ predicted by the exact solution. This construction demonstrates that a purely classical, linear optical medium can reproduce the mode-level dynamics of the MS equation exactly. We discuss the resulting refractive-index profile's physical realizability, and the prospects and open challenges for a laboratory implementation via programmable digital-optics elements.

Bryn Yehle

Physics & Astronomy Undergraduate Researcher



The Time evolution of Supernova SN 2014L

Type Ic supernovae are powerful stellar explosions that affect their surroundings and give us insights into the lives and deaths of massive stars. These supernovae are identified by a lack of hydrogen and helium in their spectra. Supernova 2014L is a Type Ic explosion with unusual hydrogen emission lines, which suggest it may be surrounded by a shell of ionized material. Using time-dependent spectropolarimetric data from the SPOL instrument, I investigate the polarization behavior of the several emission features including H α , and compare them with the supernova continuum. I will present 4 epochs of data spanning 76 days of the supernova's evolution and discuss the changing geometries of the ejecta and the hydrogen shell over time. I will compare the time dependant behavior of SN 2014L with that of two other Type Ic supernovae, SN 2012fh and SN 2014ad. This analysis reveals insights about the nature of the explosion, the circumstellar environment, and the progenitor star of SN 2014L, as well as informing our understanding of Type Ic explosions as a larger category.