Phoenix: A Far-IR Mission for Cosmology

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***Abstract*—Spectral distortions in the cosmic microwave background open a new window to the structure, content, and evolution of the universe. Detecting cosmological signals at the few part-per-billion level requires background-limited sensitivity with careful control of instrumental signatures. PHOENIX is a mission concept to map the CMB and diffuse astrophysical foregrounds with nK sensitivity at microwave through far-IR wavelengths. We describe the scientific goals of the mission and provide a summary of the predicted instrument performance.**

***Keywords*—Cosmic microwave background, Fourier transform spectrometer, instrumentation**

I. Introduction

Observations of cosmological radiation backgrounds have played a key role in our understanding of the universe. Measurements of the CMB blackbody frequency spectrum support the thermal hot big bang model while ruling out alternatives such as steady state models. Measurements of CMB anisotropies in temperature and polarization have provided insight into the contents of the universe and their evolution from primordial density perturbations to matter clustering, reionization, and the growth of large scale structure, consistent with a single 6-parameter cosmological model. Despite its success, this model is manifestly incomplete. It requires both dark energy and dark matter, neither of which exist within the Standard Model of particle physics. The observed flat geometry and nearly scale-invariant distribution of density perturbations hint at an origin in a period of exponential expansion called inflation, but direct evidence for inflation is missing.

II. Phoenix Mission

Precise measurements of the CMB introduce new opportunities to study the early universe and its evolution. Phoenix is a mission concept to measure the frequency spectrum and polarization of the CMB and astrophysical foregrounds. It will use 3 polarizing Fourier transform spectrometers (Fig 1) to map the full sky in Stokes I, Q, and U parameters to nK precision at 1.6 deg angular resolution from frequencies 20 GHz to 6 THz. With sensitivity over 1000x better than the seminal FIRAS measurements (Fig 2), Phoenix will detect the distortion from electron pressure and temperature in groups and clusters of galaxies while searching for evidence of new physics from the decay of primordial density perturbations or dark matter.

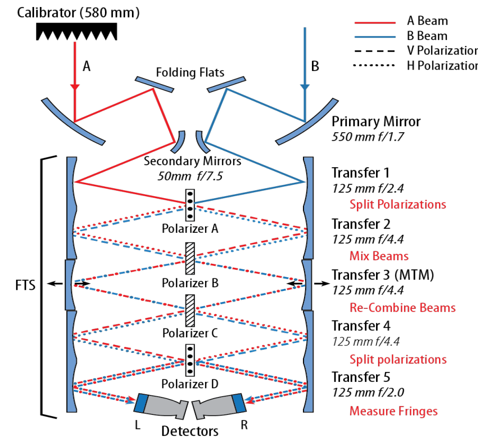

Fig 1: Schematic of the Phoenix Fourier transform spectrometer.

The instrument design provides multiple levels of null operation, signal modulation, and signal differences, with only few-percent systematic error suppression required at each level. Detailed time-ordered simulations evaluate the projected instrument performance. We describe the Phoenix mission and discuss the measures used to optimize performance.

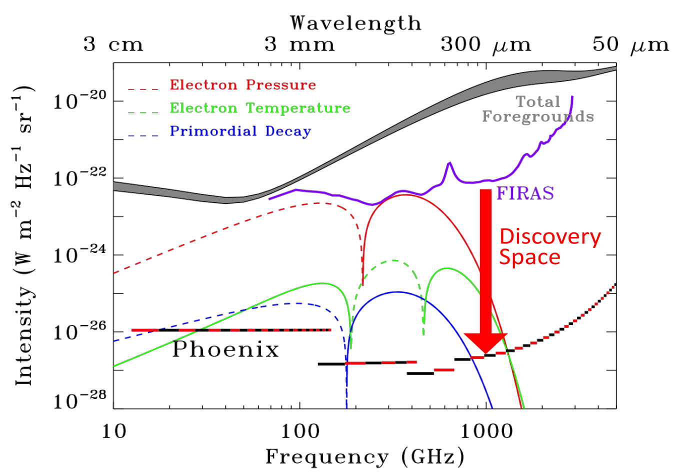

Fig 2: Phoenix will measure distortions from the CMB blackbody at sensitivity 1000x better than FIRAS, opening an enormous discovery space for cosmology and new physics while measuring the diffuse spectral signals from the low-redshift universe and our galaxy to unprecedented precision.

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