The Probe of Inflation and Cosmic Origins (PICO) is an imaging polarimeter that will scan the sky for 5 years in 21 frequency bands from 21 to 799 GHz. It will produce full-sky surveys of intensity and polarization with a final combined-map noise level equivalent to 3300 *Planck* missions for the baseline required specifications, and according to our current best-estimate would perform as 6400 *Planck* missions. With these capabilities, unmatched by any other existing or proposed platform:

• PICO could determine the energy scale of inflation and give a first, direct probe of quantum gravity by searching for the signal that arises from gravitational waves sourced by inflation and parameterized by the tensor-to-scalar ratio r. The PICO requirement is to reach $r = 5 \times 10^{-4}\,(5\sigma)$, a level that is 100 times lower than current upper limits, and 5 times lower than limits forecast by any planned experiment. If the signal is not detected, PICO is the only instrument that can exclude at 5σ models for which the characteristic scale in the potential is the Planck scale, a key threshold in inflation physics.

• The mission will measure the minimum expected sum of the neutrino masses with 4σ confidence, rising to 7σ if the sum is near 0.1 eV.

• The measurements will either detect or strongly constrain deviations from the standard model of particle physics by counting the number of light particle species $N_{\rm eff}$ in the early universe with $\Delta N_{\rm eff} < 0.06\,(2\sigma)$.

• PICO will elucidate the processes affecting the evolution of cosmic structures by measuring the optical depth to reionization τ with an error $\sigma(\tau) = 0.002$, limited only by the number of spatial modes available in the largest angular scale **CMB!** (**CMB!**) polarization.

• The data will give a full sky map of the projected gravitational potential due to all structures in the Universe with the highest **SNR!** (**SNR!**) relative to any foreseeable experiment, and it will give a catalog of 150,000 clusters extending to their earliest formation redshift. Each of these datasets will be used in combination with other data to constrain the evolution of the amplitude of linear fluctuations $\sigma_8(z)$ with sub-percent accuracy and thus constrain dark energy and modified gravity models.

• PICO will determine the cosmological paradigm of the 2030s by reducing the allowed volume of uncertainty in an 11-dimensional ΛCDM parameter space by a factor of nearly a billion relative to current *Planck* constraints on only six parameters. Such exquisite scrutiny will either give strong validation of the model or require yet-to-be discovered revisions.

• With 86,000,000 independent polarization measurements across the Milky Way, 3,000 times more than *Planck* had, PICO's data will be used to resolve long-standing questions about our Galaxy including the composition, temperature, and emissivities of Galactic dust, and the relative roles of gas turbulence and magnetic fields in the dynamics of the Galaxy and in the observed low star-formation efficiency.

• The data will constrain generic models of dark matter; enable a search for primordial magnetic fields with sufficient sensitivity to rule them out as the sole source for the largest observed galactic magnetic fields; constrain string-theory-motivated axions; and will give precise tracing of the evolution with z of thermal pressure in the universe.

• PICO's full-sky legacy maps will constrain the early phases of galaxy and cluster evolution; perform a census of cold dust in thousands of low z galaxies; make cosmic infrared background maps of the anisotropy due to dusty star-forming galaxies; and map magnetic fields in 70 nearby galaxies.

With its broad frequency coverage, PICO is better equipped than any other current or planned instrument to separate the detected signals into their orig-

Table 0.1: **Mission Parameters**

Full sky CMB polarization map depth[a] :	
Baseline	0.87 μK$_{\rm CMB}$ arcmin
	equivalent to 3300 *Planck* missions
CBE[b]	0.61 μK$_{\rm CMB}$ arcmin
	equivalent to 6400 *Planck* missions
Survey duration / start .	5 yrs / 2029
Orbit type	Sun-Earth L2

inal sources of emission. This capability is important for many of the science goals, and is critical for unveiling the faintest of signals, the telltale signature of inflation, which is already known to be dominated by Galactic foregrounds. PICO's large multiplicity of independent maps and sky surveys, and its stable thermal environment will give control of systematic uncertainties unmatched by any other platform. Mission operations are simple: PICO has a single instrument that surveys the sky with a continuously repetitive pattern. The required technologies have either already been proven by past missions, or are simple extensions of technologies now being used by sub-orbital experiments.

The science PICO will deliver addresses some of the most fundamental quests of human knowledge. Its science advances will enrich many areas of astrophysics, and will form the basis for the cosmological paradigm of the 2030s and beyond. Many of these advances can only be achieved by a space-based mission. Progress in CMB science requires a scale-up of investment. PICO is the most cost-effective way to achieve this scale-up. It has no competitor in terms of raw sensitivity, and it is the only single-platform instrument with the combination of angular resolution, frequency bands, and control of systematic effects that can deliver the compelling, timely, and broad science.