Contents

1 Scientific, Technical and Management Section

Space for Executive Summary

1.1 Science Objectives

Can ignore everything below. Here we need to explain what are the possible science objectives of the CMBProbe, how the science objectives relate to the current state of knowledge.

1.1.1 The Inflationary Gravity Wave Background

The paradigm of inflation [**?**, **?**, **?**, **?**, **?**] makes several predictions that are consistent with all current astrophysical measurements [**?**, **?**, **?**, **?**]. A robust prediction of inflation is the existence of a stochastic background of gravitational radiation with an amplitude depending on the mechanism driving the accelerated expansion [**?**, **?**, **?**, **?**, **?**]. In most scenarios, this 'inflationary gravity wave background' (IGB) is predicted to have a spatial power spectrum whose amplitude is proportional to the energy scale of inflation $V^{1/4}$ via $V^{1/4} = 3.7 \times 10^{16}\ r^{1/4}$ GeV, where V is the inflaton potential and r is the ratio of the temperature quadrupoles produced by gravity waves and by density perturbations. There are theoretical reasons $V^{1/4}$ may be close to the Grand Unification scale of 10^{16} GeV, suggesting detectable r values between $\sim$0.001 and $\sim$0.1. In addition to determining the energy scale of inflation, measurements of the IGB probe the scalar field potential at or above the Planck scale, which is particularly relevant for inflation models motivated by string theory [**?**]. Measurements of the IGB thus probe fundamental physics at the highest possible energy scales.

The most promising way to search for the IGB is through its signature on the CMB polarization [**?**, **?**]. Primordial energy density perturbations produce only a curl-free, or 'E-mode', pattern of polarization. Gravity waves also produce a curl, or 'B-mode', pattern of polarization that density perturbations cannot produce [**?**, **?**]. The amplitude of the B mode is related to the energy scale of inflation by $V^{1/4} = 2 \times 10^{16}\ (B_{peak}/0.1\,\mu\mathrm{K})^{1/2}\,\mathrm{GeV}$, where B_{peak} is the amplitude of the power spectrum of the B mode in μK at $\ell = 80$; see Fig. **??**. In its recent report New Worlds New Horizons (NWNH), the decadal survey committee strongly endorsed sub-orbital searches for the B-mode signal from inflation saying that "The convincing detection of B-mode polarization in the CMB produced in the epoch of reionization would represent a watershed discovery." [**?**]

B-mode signatures near the expected IGB peak at $\ell = 80$ have recently been detected by BICEP2 [**?**]. However, the combination of Planck data with those from the BICEP2 and Keck Array collaborations have demonstrated that the B-mode signal measured is entirely consistent with contributions from polarized emission of Galactic dust and the signal from the gravitational lensing of CMB photons by the large scale structure of the Universe (see Section **??**) [**?**, **?**, **?**]. These data give an upper limit of $r < 0.09$ at 95% confidence level. Most importantly, the constraint is largely limited by Planck's noisy measurement of the dust properties in the 353 GHz band; a noiseless dust map could shrink the constraint by a factor of two [**?**]. Further progress — detections or improved limits — requires instruments with higher sensitivity at *both* the dust and CMB frequency bands so that this Galactic foreground can be properly identified and removed.

1.1.2 Other Science Goals (Spectrum, Lensing, Neutrinos)

1.1.3 The Challenges: Foregrounds, systematics

1.1.4 Current and Forthcoming Efforts and the Role of a Space Mission

1.1.5 State of Technologies

1.1.6 Proposed Study and Management Plan

Task	Gondola	Optics + Receiver	Detectors	Readout
Task Leader	*Johnson + Tucker*[1]	*Hanany+McMahon*	*Lee*	*Dobbs*
Institution	*Columbia + Brown*[1]	*UMN+Michigan*	*UCB*	*McGill*

Task	Attitude Control	IR Filters	Foregrounds	Theory + Analysis
Task Leader	*Miller*	*Ade + Tucker*	*Baccigalupi*	Stompor, Jaffe
Institution	*Columbia*	*Cardiff*	*SISSA*	APC - Paris, Imperial

[1] Brown contributes specific separable elements to the gondola hardware

Table 1: Tasks and task leaders and institutions for the EBEX project.

2 Curriculum Vitae

3 Summary of Work Effort

Summary of Personnel and Work Efforts, (Page 1 of 2)					
Personnel	Budgeted Effort/Year (months)				
	Year 1	Year 2	Year 3	Year 4	Year 5
University of Minnesota					
Hanany, PI	1/1	1/1	1/1	1/1	1/1
Cal Tech					
Jamie Bock, Co-I	0.25	0.25	0.25	0.25	0.25
Princeton					
Lyman Page, Co-I	1/1	1/1	1/1	1/1	1/1
Goddard Space Flight Center					
Al Kogut, Co-I	0.75	0.75	0.75	0.75	0.75
[1] PDR = Post-Doctoral Researcher;					
[2] GSRA = Graduate Student Research Assistant;					

Table 2: Personnel, time in months on the project funded by NASA/time in months on the project not funded by NASA, and their role. When only one time value appears it is time funded by NASA. **Continued on next page**.

Summary of Personnel and Work Efforts, (Page 2 of 2)					
Personnel	Effort/Year (Months)				
	Year 1	Year 2	Year 3	Year 4	Year 5
Johns Hopkins					
Chuck Bennett, Co-I	0.5	0.5	0.5	0.5	0.5
NIST					
Hubmayr, Co-I	0/0.25	0/0.25	0/0.25	0	0
Lawrence Berkeley National Lab					
Borrill, Collaborator	0	0	0	0	0

4 Current and Pending Support

5 Letters of Support

6 Budget Details - Narrative

6.1 Team, Work Effort, and Budgeting Principles

6.1.1 Funded Team Members

6.1.2 Non-Funded Team Members

6.2 Costing Principles

- **Summer Salaries:**
  - **Workshop:**

6.3 University of Minnesota Budget

6.3.1 Direct Labor

6.3.2 Supplies

6.3.3 Travel

6.3.4 Other Direct Costs

Publications and Teleconferencing
Other Subcontracts

6.3.5 Facilities and Administrative Costs

7 Budget Sheets