

# CMBPol Mission Concept Study

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# this study?

To enhance the priority of inflation science within the funding agencies.

There is an opportunity to do this because the 2010 NRC Decadal Survey of Astrophysics will begin its work in the Fall 2008 and accept input from communities through early 2009.

# The Astrophysics Division of the Science Mission Directorate

solicits concept studies for  
strategic space flight science  
missions that may be carried out  
in the next decade or for which  
technology development funding is  
sought in the next decade."

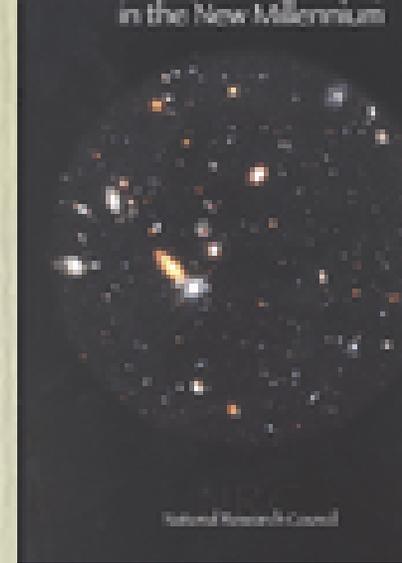
The goal of the mission concept  
studies is to develop high-quality  
scientific, technical, and cost  
information to be used for future  
mission development and

# Decadal Surveys



1990

"Bahcall"



2000

"McKee-Taylor"

The surveys take an overview of the state of astrophysics and make a prioritized list of recommendations for the upcoming decade.

The US funding agencies (NASA, NSF)

**Large Programs**

Infrared-optimized 8-m telescope	80	Space Infrared Telescope Facility (SIRTF)	1,300
Millimeter Array (MMA)	115		
Southern 8-m telescope	55		
Subtotal ground-based	250	Subtotal space-based	1,300

**Moderate Programs**

Adaptive optics	35	Dedicated spacecraft for FUSE	70
Optical and infrared interferometers	45	Stratospheric Observatory for Far-Infrared Astronomy (SOFIA)	230
Several shared 4-m telescopes	30	Delta-class Explorer acceleration <sup>a</sup>	400
Cosmic-ray telescope (Fly's Eye)	15	Astrometric Interferometry Mission (AIM)	250
Large Earth-based Solar Telescope (LEST)	15	International collaborations on space instruments	100
VLA extension	32		
Subtotal ground-based	172	Subtotal space-based	1,050

**Illustrative Small Programs<sup>b</sup>**

<i>Two-micron survey</i>	5	<i>Small Explorer acceleration</i>	100
<i>Infrared instruments</i>	10	Orbiting planetary telescope	50
<i>Cosmic background imager</i>	7	VSOP/RadioAstron	10
Laboratory astrophysics	10	Laboratory astrophysics	20
National astrometric facility	10		
300-m antenna in Brazil	10		
Stellar oscillations instrument	3		
Optical surveys	6		
Neutrino supernova watch	10		
Subtotal ground-based	71	Subtotal space-based	180

### Major Initiatives

Giant Segmented Mirror Telescope (GSMT) <sup>d</sup>	350	Next Generation Space Telescope (NGST) <sup>d</sup>	1,000
Expanded Very Large Array (EVLA) <sup>d</sup>	140	Constellation-X Observatory (Con-X)	800
Large-aperture Synoptic Survey Telescope (LSST)	170	Terrestrial Planet Finder (TPF) <sup>e</sup>	200
		Single Aperture Far Infrared (SAFIR) Observatory <sup>e</sup>	100
Subtotal ground-based	660	Subtotal space-based	2,100

### Moderate Initiatives

Telescope System Instrumentation Program (TSIP)	50	Gamma-ray Large Area Space Telescope (GLAST) <sup>d</sup>	300
Advanced Solar Telescope (AST) <sup>d</sup>	60	Laser Interferometer Space Antenna (LISA) <sup>d</sup>	250
Square Kilometer Array (SKA) technology development	22	Solar Dynamics Observatory (SDO)	300
Combined Array for Research in Millimeter-wave Astronomy (CARMA) <sup>d</sup>	11	Energetic X-ray Imaging Survey Telescope (EXIST)	150
Very Energetic Radiation Imaging Telescope Array System (VERITAS)	35	Advanced Radio Interferometry between Space and Earth (ARISE)	350
Frequency Agile Solar Radio telescope (FASR)	26		
South Pole Submillimeter-wave Telescope (SPST)	50		
Subtotal ground-based	254	Subtotal space-based	1,350

### Small Initiatives

National Virtual Observatory (NVO)	15	National Virtual Observatory (NVO)	45
Laboratory Astrophysics Program	5	Advanced Cosmic-ray Composition Experiment for the Space Station (ACCESS)	100
Low Frequency Array (LOFAR)	8	Augmentation of the Astrophysics Theory Program	30
National Astrophysical Theory Postdoctoral Program	6	Laboratory Astrophysics Program	40
Synoptic Optical Long-term Investigation of the Sun (SOLIS) expansion	8	National Astrophysical Theory Postdoctoral Program	14
		Ultralong-Duration Balloon Program	35
Subtotal ground-based	42	Subtotal space-based	264

inflation science can be on a similar list in the 2010 Decadal Report if:

- the science case is compelling
- a coherent, realistic plan exists
- the CMB community speaks in unison.

establish the fundamental importance  
inflation science.

cosmology

astrophysics

article Physics

document the experimental feasibility  
of significantly constraining  
inflationary models.

firm theoretical predictions of observables

the state of technology (two instrument  
studies)

maturity of experimental techniques

deep understanding of systematics and

Get input from the broad scientific community.

> What we agree on.

> What we do not agree on

- Document the various positions

- Identify the research and investigations needed to come to an optimum (acceptable) resolution

> Entire process is open to input from a

There will be a period of "Request for

4. Develop a path to getting the most science out of the information available in the CMB polarization measurement in the next decade.

5. Generate a report for the NRC Decadal Survey on Astrophysics.

- ▶ Influence the text of the survey
- ▶ Establish a high priority for CMB inflation science

The plan has ~~still~~<sup>been</sup> to evolve over the next four months while the study is being developed.

the most general level:

There is a programmatic hold on a start of a medium-scale space mission because of the BEPAC findings.

Much will be learned in the next 5-7 years from Planck and suborbital experiments and the research they inspire.

inggoing thoughts on the best plan  
sent to the decadal panel is:

ive a comprehensive overview of the  
importance of inflationary science  
or cosmology, astrophysics and  
physics.

utline the galactic and extra-  
galactic astrophysics which will com  
rom a CMB polarization mission.

ake an overview of the state of  
urrent technology and what we  
nticipate in the next 5 years.

being developed.

- Instrumentation
- Systematics control
- Analysis techniques
- Foreground removal

Make a strong case that this research will lead to a compelling space based mission: proposal in mid decade

**Does the plan promote a space mission now or one following 5 years of further results from suborbital experiments and**

PI  
S. Meyer

Workshop:  
Theory,  
oscillatory  
science  
foregrounds  
Dodelson

Workshop: Systematics  
Scan strategies  
Template missions  
G. Hinshaw/J. Ruhl

Workshop: Technologies  
Detector systems  
Optical systems  
K. Irwin/S. Hanany

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Detailed Study:  
Amplifier Mission  
M. Seiffert/C. Lawrence

Detailed  
Study:  
Bolometer  
Mission  
J. Bock

Detailed  
Study:  
foregrounds  
Dodelson  
Moore

Detailed  
Study:  
Lensing  
M. Zaldarriaga

Detailed  
Study:  
Scanning  
Strategies  
K. Gorski

Detailed  
Study:  
Foreground/  
feeds  
L. Page/J.  
Dunkley

Detailed  
Study:  
Optics  
A. Lee

Detailed  
Study:  
Polarization  
Systematics  
B. Keating

- Develop template missions with well defined properties

- Illustrate the capabilities we have today

- Serve as baselines for comparison of scan strategy and foreground subtraction methods

- Three templates will be used:

- EPIC, a concept proposed by Jami Bock

- An intermediate ( $\sim 10'$ ) resolution study

- A large ( $\sim 4'$ ) resolution study

- A number of small studies on

## Input from the community\*

- Wide request for participation.
  - Three workshops open to everyone on four central topics: Theory, Foregrounds, Systematics and Technology.
  - Workshop summaries with an overview which will be public and have an opportunity for input from people who are not part of the workshops.
- \* This is not just the US CMB community -- all scientists who have an interest in

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Amjad		Pablo		Lesgourgues		Peter	Shirro
Ashoorioon		Fosalba		Andrew	Liddle	Robert	Silver
Carlo		Joseph	Fowler	Adam	Lidz	Eva	
Baccigalupi		Aurelien		Michele	Liguori	Silverstein	
Nicola	Bartolo	Fraisse		Eugene	Lim	Jean	Slaugh
Daniel	Baumann	Todd	Gaier	Marilena	Loverde	Eric	Smith
Rachel	Bean	Nick	Gnedin	Antonio		Kendrick	Smith
Maria	Beltran	Krzysztof	Gorski	Magalhaes		Tristan	Smith
Dominic	Benford	Joshua		Mario		Glenn	Stark
Chuck	Bennett	J Gundersen		Magalhaes		Albert	Stebb
ames	Bock	Shaul	Hanany	John		Jason	Steffe
Julian	Borrill	Makoto		Marriner		Radek	Stomp
Latham	Boyle	Hattori		Victoria	Martin	Osamu	Tajima
Emory	Bunn	Marijke		Sabino		Peter	Timbi
Clarence	Chang	Haverkorn		Matarrese		Takayuki	Tomaru
Xingang	Chen	Masashi	Hazumi	Harsh	Mathur	Ray	Tomlin
Daniel	Chung	Mark		Benjamin	Mazin	Huan	Tran
Sarah	Church	Hertzberg		Liam		Gregory	Tucker
David	Chuss	James		McAllister		Amol	Upadhy
Asantha	Cooray	P Hinderks		Jeff	McMahon	John	
aolo		Gary		Alessandro		Vaillancourt	
Creminelli		Hinshaw		Melchiorri		Wessel	Valke
Sudeep	Das	C Chris	Hirata	Gary	Melnick	Pascal	
live		Wayne	Hu	Stephan	Meyer	Vaudrevange	
Dickinson		Howard	Hui	Amber	Miller	Marcellla	Venez
Michael	DiPirro	Kent	Irwin	Michael		Licia	Verde
Matt	Dobbs	Mark		Mortonson		oaquin	Vieira
Greg	Dobler	Jackson		Samuel	Moseley	Andre	Waelk
Scott		onnie	Jansson	Hogan	Nguyen	Ben	Wande
Dodelson		Brad		Alberto	Nicolis	David	Wands
Olivier	Dore	Johnson		Peng	Oh	Scott	Watson
Jessie	Dotson	Dean		Lyman	Page	William	Weste
Thomas	Downes	Johnson		Hiranya	Peiris	Bruce	Winst
William	Duncan	William	Jones	John	Peoples	Edward	Wolla
Joanna	Dunkley	Katherine	Jones-	Nicolas		Maik	Wolle
Cora	Dvorkin	Smith		Phillips		Mark	Wyman
				Elena			

• Input from the community (continued)

- Workshop on theory and foregrounds last month
  - Organized by Scott Dodelson
  - Inflation
  - Reionization
  - Lensing
  - Foreground removal
  - Foreground science

- Organized by Gary Hinshaw and John Ruhoff
- Experience from experiments with data
- Plans for experiments in development and future
- Experiment simulation and analysis

## - Workshop on Technology in late August

- Organized by Shaul Hanany and Kent Irwin
- Detection techniques
- Optical coupling
- Bands and filters
- Readouts

## Input from the community (continued)

- A group of participants will write a summary of each of the topics in the workshops.
- These will be summarized by the workshop organizers into a proceedings.
- The workshop proceedings along with presentation slides will be on the CMBpol website.
- They will provide the basis for the report to the decadal.

sections of the report based on the workshop proceedings.

- Drafts of the report will be on the CMBPol website for comment.
- In November, the report will be sent to reviewers, outside the CMB field.
- Starting in late December, the writing group will generate the final report based on the reviewer comments.

• A final workshop in Chicago which summarizes the report in March 2009

# Information

[://cmbpol.uchicago.edu](http://cmbpol.uchicago.edu)

Theory Workshop, June 23 - 26, 2008  
armilab

[://astro.fnal.gov/cmb/Welcome.html](http://astro.fnal.gov/cmb/Welcome.html)

Systematics Workshop, July 28 - 30,  
2008, Annapolis, MD

[://cmbpol.uchicago.edu/workshops/systematic2008](http://cmbpol.uchicago.edu/workshops/systematic2008)

Technology Workshop, August 25 - 28  
2008, Boulder, CO

[://cmbpol.uchicago.edu/workshops/technology2008](http://cmbpol.uchicago.edu/workshops/technology2008)

the CMB is a unique property of the universe.

If the past decade is any guide, it would be wise to assume that the information it provides, beyond what will come of the next generation of experiments, will be important in ways we do not yet know.