

NRC Study: From Quarks to the Cosmos

Summary

The Committee on the Physics of the Universe will carry out an assessment of an area of science at the intersection of physics and astronomy. The study will provide a broad vision that goes beyond traditional categories of space missions, laboratory studies, telescope observations, and accelerator experiments. It will focus on opportunities for breakthroughs in understanding the birth, evolution and destiny of the Universe, the laws that govern it, and even the nature of space and time. The assessment would encompass astrophysical and cosmological phenomena that give insight into fundamental physics and fundamental physics that is relevant to understanding the universe and the diversity objects within it. It will address opportunities to explore new science through (1) new techniques for observing phenomena in extreme environments and new regimes, (2) new applications of fundamental physics to modeling and simulating the origin, evolution, and fate of the universe, and (3) understanding fundamental physics by using space and the cosmos as a laboratory full of experiments that could never be implemented on the Earth.

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Complementary to Astronomy and Physics Decadal Surveys

COMMITTEE ON THE PHYSICS OF THE UNIVERSE

15 Physics-aware Astronomers & Astronomy-aware
Physicists, 8 meetings, community input

Two years, two phases

Phase I: Identify timely science opportunities
(200 page report)

Phase II: Set priorities and suggest mechanisms for
cooperation and coordination between agencies

NB: Not a reassessment of Physics and Astronomy Surveys

THE SCIENCE

*NATURE OF MATTER, SPACE AND TIME
(Unification, Gravity Beyond Einstein)*

*BIRTH OF THE UNIVERSE
(Earliest evolution of the Universe)*

NATURE OF THE DARK MATTER AND DARK ENERGY

*TESTING THE KNOWN PHYSICAL LAWS IN EXTREME
ENVIRONMENTS/SEEKING NEW LAWS*

Physics and Astronomy are inextricably connected in these
deep, fundamental questions

Committee on the Physics of the Universe

- Michael Turner (Chicago),
Chair
- Roger Blandford (Caltech)
- Sandra Faber (Santa Cruz)
- Thomas Gaisser (Bartol)
- Fiona Harrison (Caltech)
- John Huchra (Harvard)
- Helen Quinn (SLAC)
- R.G.H. Robertson (U Wash)
- Bernard Sadoulet (Berkeley)
- Frank Sciulli (Columbia)
- David N. Spergel (Princeton)
- J. Anthony Tyson (Lucent)
- Frank Wilczek (MIT)
- Clifford Will (Wash U)
- Bruce Winstein (Chicago)
- Don Shapero, Director
- Joel Parriott, Staff Officer

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FROM QUARKS TO THE COSMOS TIMELINE

PHASE I (Identify Timely Science Opportunities)

November 1999: BPA Forum, Physics in Space, and request by Administrator Goldin for NRC Study (Irvine, CA)

February 2000: Formation of CPU

March 2000: 1st Meeting, Report Outline

April 2000: CPU Presentation at APS April Meeting (Long Beach)

May 2000: CPU Presentation to National Science Board

June 2000: CPU Presentation to AAS; Second Meeting of CPU (discuss first draft of report)

August 2000: Telcon to discuss Science Opportunities/Priorities

August 2000: Presentation at DPF (OSU)

PHASE II (Set Priorities and Suggest Mechanisms for Coordination)

October 2000: 3rd Meeting of CPU (phase I report complete);
planning for Phase II

December 2000: Presentation of Phase I report
(Texas Symposium on Relativistic Astrophysics; Austin, TX)

January 2001: Presentation of Phase I report; 4th meeting of
CPU, Public Forum on Opportunities (San Diego AAS Meeting)

April 2001: Science Sessions (DAP, DPF, DNP, Gravity); Public
Forum on Opportunities; 5th meeting of CPU (Wash, DC APS)

June 2001: Snowmass, CO; 6th Meeting of CPU; Public Forum
on Opportunities

Fall 2001: 7th and 8th Meetings of CPU

January 2002: Phase II Report Complete

Report Outline

FROM QUARKS TO THE COSMOS

Chapter 1: Introduction

Where we are now, Where we could be 15 years from now

Chapter 2: Nature of Matter, Space and Time?

Gravity beyond Einstein; unification of the forces

Opportunities: Neutrino mass/mixing; Deviations from std gravity;
Extra-dimensions; Signatures of unification

Chapter 3: How did the Universe begin?

Origin and earliest evolution of the Universe:

Opportunities: Test inflation; Determine inflationary parameters;
'Listen' to phase transitions

Chapter 4: What is the dark matter and dark energy?

What holds the Universe together; why is it accelerating?

Opportunities: Determine nature of dark energy; Identify dark matter particle;
Map distribution of dark matter

Chapter 5: What are the limits of the known physical laws?

Extreme environments: plasmas, extremes in B, density, gravity;
ultra-high energy cosmic rays, photons and neutrinos; solar neutrinos

Opportunities: Explore gravity in new regimes (gravity waves and strong field);

Origin and nature of UHE Cosmic Rays, gamma rays and neutrinos;

Neutron stars as nuclear physics lab

Chapter 6: Connections to Astronomy, Physics and Technology

Astronomy; Particle, Nuclear, Plasma, Gravitational Physics;

Enabling technologies

Chapter 7: Institutional Issues

Unique features and strengths of DOE, NASA, NSF;

Past experiences (e.g., LHC, GLAST, AMS);

Model mechanisms for cooperation (eg, SAGENAP, NSAC, CAA)

Chapter 8: Infrastructure

Computing, theory, underground laboratory, ...