NASA’s Physics of the Cosmos Program

Jamie Bock

California Institute of Technology

Chair of the Physics of the Cosmos Program Analysis Group

pcos.gsfc.nasa.gov
Physics of the Cosmos Program seeks to understand the nature of the Universe. What are its constituents? What are the laws that govern its birth and evolution?

Dark Energy: Probe the nature of dark energy by studying the expansion rate of the universe and the growth of structure.

Inflation: Test the theory of inflation by measuring the polarization of the Cosmic Microwave Background.

Black Holes & General Relativity: Probe the properties of black holes and test General Relativity in strong gravity environments using x-ray emission and gravitational waves.

Behavior of Matter in Extreme Environments: Explore extreme astrophysical processes with Cosmic rays, X-rays and Gamma-rays.
PhysPAG and SIGs

• PhysPAG has six SIGs in operation:
  – Inflation Probe SIG (Chair: Amber Miller and Ed Wollack)
  – Gravitational Wave SIG (Chair: Neil Cornish)
  – X-ray SIG (Chair: Jay Bookbinder and Mark Bautz)
  – Gamma ray SIG (Chair: Mark McConnell)
  – Cosmic Ray SIG (Chair: Eun-Suk Seo)
  – Cosmic Structure SIG (Chair: Olivier Doré, Rachel Bean)
**Inflation Probe SIG**

*General interest:*

US MO participation in Japanese LITEBIRD mission selected for phase A study
SPHEREx SMEX mission concept selected for phase A study (inflation & large-scale structure)

*Ongoing activities:*

DOE Stage-4 CMB polarization meeting held in Ann Arbor, MI 21-22 September

*Upcoming activities:*

DOE Stage-4 CMB polarization meeting in Berkeley, CA
Upcoming CORE++ proposal for ESA M5 proposal opportunity

**Gravitational Wave SIG**

*General interest:*

LISA Pathfinder shipped 8 October to Kourou. Launch planned 2 December.

*Upcoming activities:*

SIG meeting at the AAS, Kissimmee, January 2016
SIG meeting at the APS, Salt Lake City, April 2016
LISA Symposium, Zurich, September 2016

*Excluding the main activity for all SIGs this year: The Flagship Mission Studies Report*
SIG Activities

X-Ray SIG

General interest:
Two X-Ray polarimetry SMEX mission concepts (IXPE and PRAXys) selected for phase A study
Astrosat, an Indian X-ray/UV/Optical astronomy satellite launched 28 September

Ongoing activities:
‘Probing the Universe in Depth and Detail with the X-Ray Surveyor’ held in Washington DC 6-8 October

Upcoming activities:
SIG meeting at the AAS, Kissimmee, January 2016
SIG meeting at AAS/HEAD, Naples, April 2016

Gamma-Ray SIG

Ongoing activities:
Develop gamma-ray astronomy roadmap for input to the 2020 decadal survey focusing on probe-class and explorer-class concepts

Upcoming activities:
SIG meeting at the Fermi Workshop, 9-13 November
SIG meeting at the AAS, Kissimmee, January 2016; science requirements for mission concepts
SIG meeting at AAS/HEAD, Naples, April 2016; instrument concepts
SIG Activities

Cosmic-Ray SIG

**General interest:**
- ISS-CREAM completed testing at GSFC and delivered to KSC
- CALET (Japanese-led mission for high-energy cosmic-ray electrons) launched in August to ISS

**Upcoming activities:**
- SIG meeting at the AAS, Kissimmee, January 2016
- SIG meeting at the APS (TBC) Salt Lake City, April 2016

Cosmic Structure SIG

**General interest:**
- SPHEREx SMEX mission concept selected for phase A study (inflation & large-scale structure)

**Ongoing activities:**
- Set up PCOS web page and email list

**Upcoming activities:**
- Town hall meeting at the AAS, Kissimmee, January 2016
## PhysPAG EC membership

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Topical Area</th>
<th>Term end</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. Bock, Chair</td>
<td>Caltech/JPL</td>
<td>CMB</td>
<td>December 2016</td>
</tr>
<tr>
<td>M. Bautz, Vice Chair</td>
<td>MIT</td>
<td>X-rays</td>
<td>December 2016</td>
</tr>
<tr>
<td>R. Bean</td>
<td>Cornell Univ.</td>
<td>Dark Energy</td>
<td>December 2016</td>
</tr>
<tr>
<td>J. Bookbinder</td>
<td>SAO</td>
<td>X-rays</td>
<td>December 2015</td>
</tr>
<tr>
<td>J. Conklin</td>
<td>Univ. of Florida</td>
<td>Gravitational Waves</td>
<td>December 2017</td>
</tr>
<tr>
<td>N. Cornish</td>
<td>Montana State</td>
<td>Gravitational Waves</td>
<td>December 2016</td>
</tr>
<tr>
<td>O. Doré</td>
<td>JPL</td>
<td>Dark Energy</td>
<td>December 2017</td>
</tr>
<tr>
<td>H. Krawczynski</td>
<td>Washington Univ. in St. Louis</td>
<td>Gamma-rays</td>
<td>December 2017</td>
</tr>
<tr>
<td>M. McConnell</td>
<td>U. of New Hampshire</td>
<td>Gamma-rays</td>
<td>December 2016</td>
</tr>
<tr>
<td>A. Miller</td>
<td>Columbia Univ.</td>
<td>CMB</td>
<td>December 2017</td>
</tr>
<tr>
<td>J. Nousek</td>
<td>PSU</td>
<td>X-rays</td>
<td>December 2015</td>
</tr>
<tr>
<td>A. Olinto</td>
<td>Univ. of Chicago</td>
<td>Astroparticles</td>
<td>December 2015</td>
</tr>
<tr>
<td>Eun-Suk Seo</td>
<td>U. of Maryland</td>
<td>Astroparticles</td>
<td>December 2016</td>
</tr>
<tr>
<td>E. Wollack</td>
<td>NASA/GSFC</td>
<td>CMB</td>
<td>December 2017</td>
</tr>
</tbody>
</table>

Evaluation for replacement members currently in process
PCOS Gap Technologies

• PhysPAG reviewed and edited submitted gap technologies
  – Merged with existing items where applicable to simplify prioritization
  – Made a uniform format for anticipated need date
  – Presented to PCOS TMB who prioritized 22 items

Priority 1
1. High-power, narrow-line-width laser sources.
3. Large-format, high-spectral-resolution, small-pixel X-ray focal-plane arrays.
4. Affordable, lightweight, high-resolution X-ray optics.
5. Advanced millimeter-wave focal plane arrays for CMB polarimetry.
6. High-efficiency cooling systems covering the range 20K to under 1K.

Priority 2
1. Phase-measurement subsystem (PMS).
2. Millimeter-wave optical elements.
3. Low-stress or stress-free coating for X-ray optical elements.
4. Low-mass, long-term stability optical bench.
5. Fast, low-noise megapixel X-ray imaging array with moderate spectral resolution.

Priority 3
1. Very-wide-field focusing instrument for time-domain X-ray astronomy.
2. Ultra-high-resolution focusing X-ray observatory telescope.
3. Advancement of X-ray polarimeter sensitivity with the use of negative-ion gas.
4. Fast, few-photon UV detectors.
5. Lightweight large-area reflective optics.
6. Low-power time-sampling readout.
7. Low-power comparators and logic arrays.
8. Lattice optical clock for Solar Time Delay mission and other applications.