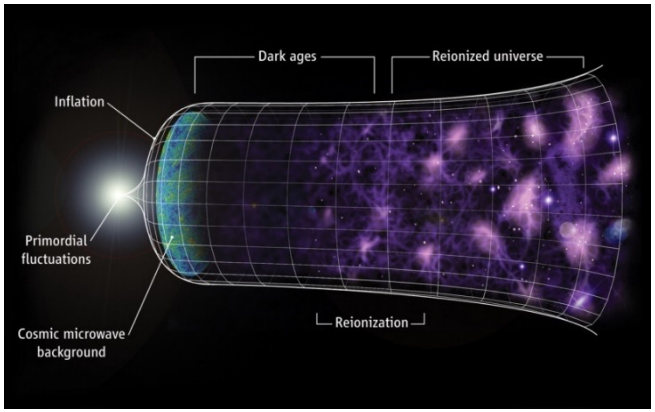
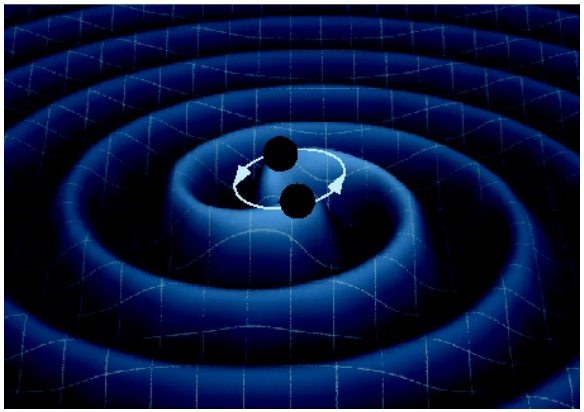
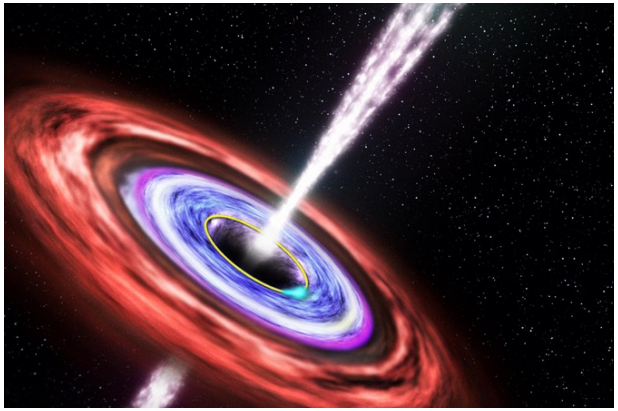
# Physics of the Cosmos Program Analysis Group Report





**Ryan Hickox**

Dartmouth College
*Chair, Physics of the Cosmos Program Analysis Group, PhysPAG*
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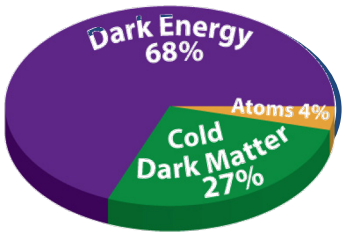
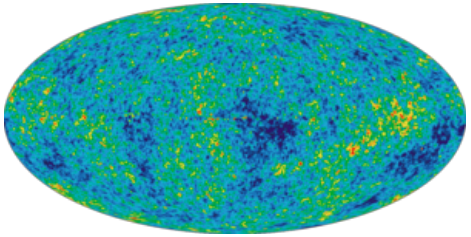
*Astrophysics Advisory Committee Meeting, 29 June 2021*

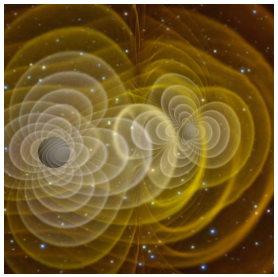
# Outline

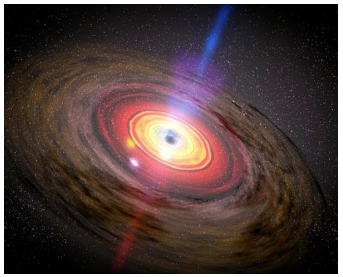
- **Introduction to PhysPAG (reminder)**
- **PhysPAG Activities at APS**
- **PhysPAG/SIG Meetings and Activities**

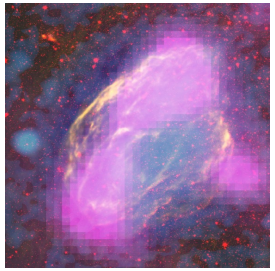
# Physics of the Cosmos Science Objectives









- **Increase our knowledge of dark energy**
- **Precisely measure cosmological parameters governing evolution of the universe and test inflation hypothesis of Big Bang**
- **Test validity of Einstein's General Theory of Relativity and investigate nature of spacetime**
- **Understand formation and growth of massive black holes and their role in evolution of galaxies**
- **Explore behavior of matter and energy in its most extreme environments**

# Physics of the Cosmos Program Analysis Group (PhysPAG)

## Science Analysis Groups (SAGs)

- **Multimessenger Astrophysics** (MMA SAG) (Chairs: Kevin Huffenberger): Analyze the potential scientific benefits of multimessenger observations made possible by NASA observatories in the 2020 decade and beyond, working in conjunction with each other or with other ground and space-based instruments.

## Science Interest Groups (SIGs)

- **Inflation Probe** (IP SIG) (Chairs: Kevin Huffenberger and Graça Rocha): Coordinate community activities and preparations for a future cosmic microwave background polarization mission.
- **Gravitational Wave** (GW SIG) (Chairs: Jillian Bellovary and Sean McWilliams): Coordinate community activities and preparations for a future gravitational wave mission.
- **X-ray** (XR SIG) (Chairs: Ryan Hickox, Jillian Bellovary, and Grant Tremblay): Coordinate community activities and preparations for a future X-ray astronomy mission.
- **Gamma Ray** (GR SIG or GammaSIG) (Chairs: Marcos Santander, Bindu Rani, and Justin Finke): Coordinate community activities and preparations for a future gamma ray astronomy mission.
- **Cosmic Ray** (CR SIG) (Chairs: Marcos Santander and Andrew Romero-Wolf): Coordinate community activities and preparations for a future cosmic ray astronomy mission.
- **Cosmic Structure** (CoS SIG) (Chairs: Kevin Huffenberger, Graça Rocha, and Vera Gluscevic): Coordinate community activities for future space activities concerning the nature of dark energy, dark matter, neutrinos, and tests of inflation, as well as astrophysical galaxy evolution.

# PhysPAG EC Membership

| Name | Affiliation | Area of Expertise | Term Ends |
|---|---|---|---|
| Graça Rocha (Chair Emeritus) | JPL/Caltech | GW SIG | Dec 2021 |
| Ryan Hickox (Chair) | Dartmouth College | XR SIG | Dec 2021 |
| Marcos Santander | Univ. of Alabama | CR SIG / GR SIG | Dec 2021 |
| Jillian Bellovary | Queensborough Comm Coll. | GW SIG / XR SIG | Dec 2022 |
| Sean McWilliams | WVU | GW SIG | Dec 2022 |
| Bindu Rani | SURA, GSFC | GR SIG | Dec 2022 |
| Grant Tremblay (Vice-Chair) | SAO | XR SIG | Dec 2022 |
| Justin Finke | NRL | GR SIG | Dec 2023 |
| Vera Glusevic | Univ. of Southern California | CoS SIG | Dec 2023 |
| Andres Romero-Wolf | JPL | CR SIG | Dec 2023 |

# PhysPAG Activities at APS

PhysPAG organized or contributed to 6 sessions at virtual **April APS**

**PCOS and PhysPAG Town Hall Minisymposium (Session B21)**

**Sponsoring Division**: DGRAV, DAP
**When**: Saturday 17 April 2021, 11:45 AM Eastern/10:45 AM Central/9:45 AM Mountain/8:45 AM Pacific
**Chair**: Graça Rocha (NASA JPL)

**Agenda**

**ALL TIMES GIVEN FOR TALKS ARE CENTRAL DAYLIGHT TIME**

| | |
|---|---|
| 10:45–10:57 | Brian Williams (NASA GSFC) – Overview of PCOS [PDF] |
| 10:57–11:09 | Ryan Hickox (Dartmouth) –Overview of PhysPAG [PDF] |
| 11:09–11:33 | Joe Silk (Johns Hopkins) – Unveiling the Early Universe with the Spectral Distortions of the CMB [PDF] |
| 11:33–11:57 | Joseph Lazio (NASA JPL) – Extending the Cosmic Frontier into the Dark Ages [PDF] |
| 11:57–12:21 | Jack Burns (U. Colorado) – A Lunar Farside Low Radio Frequency Array for Dark Ages 21-cm Cosmology [PDF] |
| 12:21–12:33 | Grant Tremblay (Harvard) – The Once & Future Great Observatories |

# the Cosmic Ray Science Interest Group highlights and updates

## ❑ Cosmic Ray SIG

- Co-chairs: Andres Romero-Wolf (JPL) and Marcos Santander (U. Alabama).
- Recent and upcoming CR-SIG activities:
  - Organized **mini-symposium** at the April APS Meeting on ultra-high-energy cosmic rays and neutrino observations, including future space-and balloon-based missions (ZAP, PUEO, EUSO-SPB2, POEMMA).

| | |
|---|---|
| 1:30–1:35 | Marcos Santander (U. Alabama) – Welcome and Introduction to the CR-SIG [PDF] |
| 1:35–2:10 | Frank Schroeder (U. Delaware) – Ultra-high-energy Cosmic Rays: Recent Results and Future Plans [PDF] |
| 2:10–2:27 | Andres Romero-Wolf (NASA JPL) – Particle Astrophysics at Zettavolt Energies with Radio Detectors in Low Lunar Orbit [PDF] |
| 2:27–2:44 | Remy Prechelt (U. Hawaii) – Prowling for Ultrahigh Energy Neutrinos with PUEO [PDF] |
| 2:44–3:01 | Lawrence Wiencke (Colorado School of Mines) – The EUSO-SPB2 Mission [PDF] |
| 3:01–3:18 | Angela V. Olinto (U. Chicago) & John Krizmanic (NASA GSFC) – The Roadmap to the POEMMA Mission [PDF] |

  - A **webinar series** targeting future missions is in the works.

# the Gamma Ray Science Interest Group highlights and updates

## ❑ GR SIG

- Co-Chairs: Bindu Rani, Marcos Santander, Justin Finke

- Organized April 2021 APS session on time-domain astrophysics

| | |
|---|---|
| 3:45–3:50 | Bindu Rani (NASA GSFC) – Gamma Ray SIG Overview [PDF] |
| 3:50–4:14 | Dave Thompson (NASA GSFC) – Maximizing the Scientific Return of the Time Domain Astronomy [PDF] |
| 4:14–4:38 | Raffaella Margutti (Northwestern U.) – Gamma-ray Novae [PDF] |
| 4:38–5:02 | Jamie Holder (U. Delaware) – Gamma-ray Transients [PDF] |
| 5:02–5:26 | Elias Aydi (Michigan State U.) – Gamma-ray Binaries |
| 5:26–5:33 | Open Discussion |

- Organized June 2021 AAS session on solar astrophysics

| | | |
|---|---|---|
| 4:10–4:12 | Welcome & Overview | Justin Finke |
| 4:12–4:34 | Fermi-LAT Solar Flare Catalog: Observations of Solar Flares at High Energy During Solar Cycle 24 [PDF] | Nicola Omodei |
| 4:34–4:56 | Exploring the Sun-Galaxy Connection with GeV Gamma Rays [PDF] | Annika Peter |
| 4:56–5:18 | The Sun as a Target for Very-High-Energy Gamma-ray Observations [PDF] | Mehr Un Nisa |
| 5:18–5:40 | Understanding the Sun via Gamma-ray Lines [PDF] | Albert Shih |

- COSI (γ-ray SMEX) and LEAP (γ-ray MO) delivered concept studies to NASA

# the Gravitational Waves Science Interest Group highlights and updates

## ❑ GW SIG

- Co-Chairs: Jillian Bellovary, Sean McWilliams

**Upcoming plans:**

- organize a multi-messenger session (GW + EM) covering the full spectrum of frequencies and masses at the winter AAS
- organize a GW astrophysics in the next decade, with emphasis on decadal recommendations, at the Spring APS

# the Inflation-Probe Science Interest Group highlights and updates

## ❑ IP SIG

- Organized session at virtual April APS

| | |
|---|---|
| 1:30–1:37 | Graça Rocha (NASA JPL) – Inflation Probe SIG Overview [PDF] |
| 1:37–1:53 | Shaul Hanany (U. Minnesota) – Science Reach of PICO – a New, Probe-Class CMB Space Mission [PDF] |
| 1:53–2:09 | Adrian Lee (UC Berkeley) – LiteBIRD Overview [PDF] |
| 2:09–2:25 | Al Kogut (NASA GSFC) – The Primordial Inflation Polarization Explorer (PIPER): Testing Inflation on Large Angular Scales |
| 2:25–2:41 | Jeff Filippini (U. Illinois) – The First Flight of SPIDER: Probing Inflation from the Stratosphere [PDF] |
| 2:41–2:46 | Discussion |
| 2:46–2:53 | Mathieu Remazeille (U. Manchester) – Forecasts on Foregrounds Removal and CMB B-mode Recovery with the Probe-class Mission Concept PICO [PDF] |
| 2:53–3:00 | Rahul Datta (Johns Hopkins) – The Primordial Inflation Polarization Explorer (PIPER): Characterization of the Receiver and Detector Arrays [PDF] |
| 3:00–3:07 | Johanna Nagy (Wash. U. St Louis) – Foreground Component Separation for SPIDER's Primordial B-mode Constraint [PDF] |
| 3:07–3:14 | TBA – LiteBIRD related |
| 3:14–3:18 | Discussion |

# the Cosmic Structure Science Interest Group highlights and updates

## ❑ CoS SIG

- Organized session at virtual April APS

| | |
|---|---|
| 10:45–10:55 | Kevin Huffenberger (Florida State U.) – Update on Cosmic Structure SIG [PDF] |
| 10:55–11:25 | Elisabeth Krause (U. Arizona) – Update on SPHEREx |
| 11:25–11:55 | Kris Pardo (NASA JPL) – Update on Roman Space Telescope [PDF] |
| 11:55–12:33 | Open Discussion [PDF] |

- Ongoing discussions about **expanding CoSSIG** to include **COPAG** and well as **PhyPAG**

# the X-ray Science Interest Group highlights and updates

## ❑ X-Ray SIG

- Organized session on ” X-ray astrophysical constraints on fundamental physics” for April APS

| | |
|---|---|
| 1:30–1:42 | Ryan Hickox (Dartmouth) – Introduction to XRSIG and Highlights in X-ray Astronomy [PDF] |
| 1:42–2:06 | Sharon Morsink (U. Alberta) – The Neutron Star Equation of State with NICER [PDF] |
| 2:06–2:30 | Mengjiao Xiao (MIT) – Constraints on Axionlike Particles from a Hard X-Ray Observation of Betelgeuse [PDF] |
| 2:30–2:54 | Dominic Sicilian (U. Miami) – X-ray Constraints on Sterile Neutrino Dark Matter [PDF] |
| 2:54–3:18 | Grant Tremblay (Harvard), Jillian Bellovary (CUNY QCC), and Ryan Hickox (Dartmouth) – Open Business and Discussion |

- Plans for Winter AAS SIG session on X-ray Surveys

# Upcoming Meetings and Activities

- **Winter AAS, January 2022, Salt Lake City**
  - Will have **five SIG sessions** plus **one Town Hall**

- **SACNAS and NSBP:**
  Led cross-PAG proposal for session at **SACNAS National Diversity in STEM meeting** in October, on **"Exploring the Universe with the NASA Astrophysics Community"** (submitted early June; selections announced July). Also planning for session at **NSBP** in November

- **Regular meetings of PhysPAG EC, SIGs, and organization of potential SAGs**