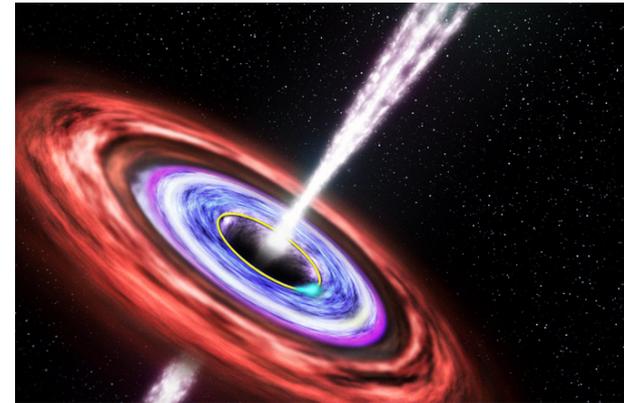
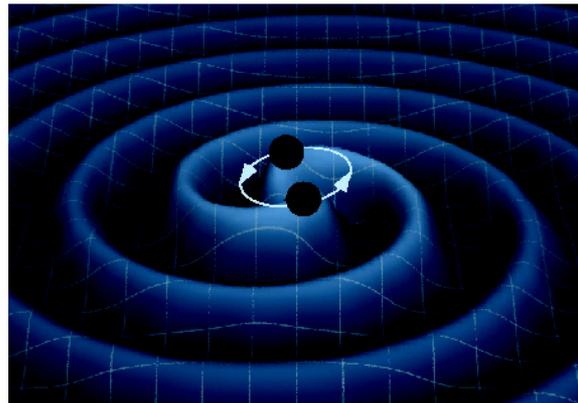
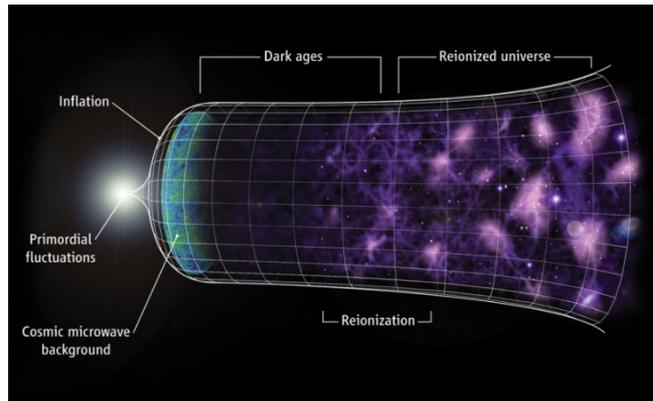
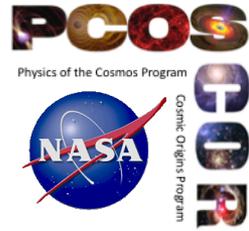


# Physics of the Cosmos Program Analysis Group Report



**Ryan Hickox**

Dartmouth College  
*Chair, Physics of the Cosmos Program Analysis Group, PhysPAG*  
*ryan.c.hickox@dartmouth.edu*

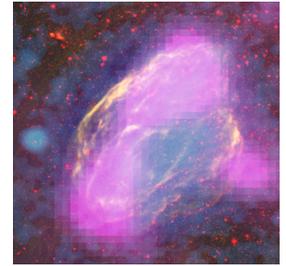
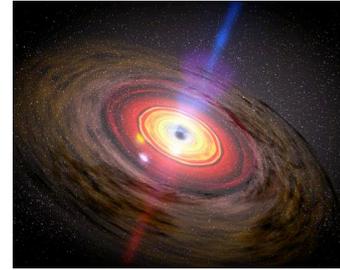
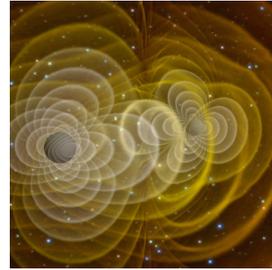
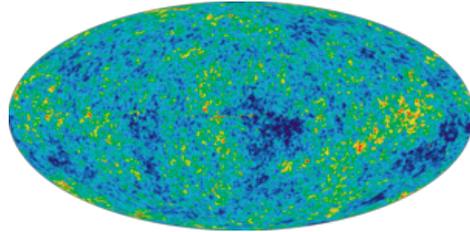
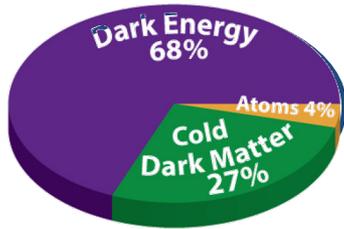
*Astrophysics Advisory Committee Meeting, 16 March 2021*

# Outline

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- **Introduction to PhysPAG (reminder)**
- **PhysPAG Activities at AAS**
- **Cross-PAG initiatives**
- **Proposed SAG in Expanding Participation in NASA Astrophysics**
- **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

## 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

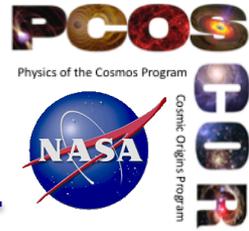


Name	Affiliation	Area of Expertise	Term Ends
Graça Rocha (Chair Emeritus)	JPL/Caltech	GW SIG	Dec 2021
Ryan Hickox (Chair)	Dartmouth College	XR SIG	Dec 2021
Marcos Santander	Univ. of Alabama	CR SIG	Dec 2021
Jillian Bellovary	Queensborough Comm Coll.	GW SIG / XR SIG	Dec 2022
Sean McWilliams	WVU	GW SIG	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

\* New Roles

\*New members as of January 2021

# PhysPAG Activities at AAS



PhysPAG organized or contributed to eight sessions at virtual  
**January AAS**

## PCOS Program Analysis Group (PhysPAG)

Monday, 11 January 2021, 12:00 Noon

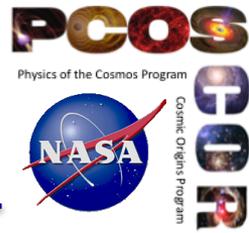
Chair: Grant Tremblay

### Agenda

- **PCOS Overview** [PDF] – Brian Williams, GSFC (15 + 5 mins)
- **PhysPAG Overview** [PDF] – Graça Rocha, JPL/Caltech (15 + 5 mins)
- **X-ray Highlights** [PDF] – Ryan Hickox, Dartmouth College (15 + 5 mins)
- **Looking forward to LISA: Binary Supermassive Black Holes** [PDF] – Krysta Lynne Smith, SMU (15 + 5 mins)
- **Discussion** (10 mins)

# the Cosmic Ray Science Interest Group highlights and updates

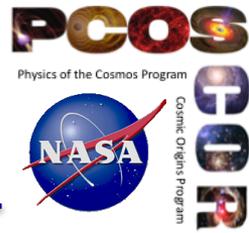
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## □ Cosmic Ray SIG

- Current co-chairs: Andres Romero-Wolf (JPL) and Marcos Santander (Univ. of Alabama).
- Science focus of the group has **broadened to include high-energy neutrinos** reflecting the interest of the community.
- News: PUEO, balloon mission to detect ultra-high-energy neutrinos, selected as part of the Pioneers Program.
- Recent and upcoming CR-SIG activities:
  - Joint multi-messenger (CR-GR-GW SIGs) session at the virtual 237th AAS Meeting (Jan 2021). ~60 attendees during the session.
  - CR-SIG mini-symposium at the 2021 APS April meeting. Theme: “Ultra-high-energy cosmic particles, current status and future directions”. Invited overview talk and contributed presentations on EUSO-SPB2, POEMMA, PUEO and ZAP missions.
  - The co-chairs will start organizing regular webinars on missions or science topics of interest to the SIG.

# the Cosmic Ray Science Interest Group highlights and updates



## Multi-SIG Session on the Status of Multimessenger Astrophysics (MMA)

Tuesday, 12 January 2021, 12:00 Noon

Chair: Marcos Santander

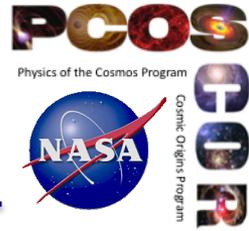
### Agenda

- **Invited: Multimessenger Astrophysics at NASA's Goddard Space Flight Center** [[PDF](#)] – Rita Sambruna (NASA GSFC) (30 min talk)
- **Gamma-rays and Gravitational Waves** [[PDF](#)] – Michelle Hui (NASA MSFC) (15 min talk)
- **Gamma-rays and Neutron Star Mergers** [[PDF](#)] – Imre Bartos (University of Florida) (15 min talk)
- **Future Gamma-ray Missions for MMA: BurstCube, AMEGO-X, and AMEGO** [[PDF](#)] – Judy Racusin (NASA GSFC) (15 min talk)
- **AstroPix: Investigating the Potential of Silicon Pixel Sensors in the Future of Gamma-ray Astrophysics** [[PDF](#)] – Isabella Brewer (University of Maryland) (15 min talk)

# the Gamma Ray Science Interest Group

## highlights and updates

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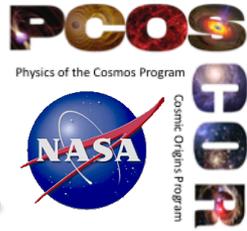


### □ GR SIG

- Bindu Rani, **Marcos Santander, Justin Finke (new, Dec 2020)**
- StarBurst gamma-ray burst mission selected through NASA Pioneer program
- Joint multi-messenger session (GW-GR-CR SIGs) at January 2021 AAS meeting
- Organizing April 2021 APS session on time-domain astrophysics
- Organizing June 2021 AAS session on solar astrophysics

# the Gravitational Waves Science Interest Group

## highlights and updates



### □ GW SIG

- Organized session at virtual January AAS as well as combined CR-GR-GW SIG session
- Some science highlights: Summary of results from LIGO O3A; a transient “anomaly” in NANOGrav data; a correlated “red noise process” in NANOgrav that could be a low significance gravitational wave signal

#### **Gravitational Wave SIG**

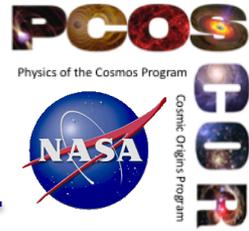
Thursday, 14 January 2021, 12:00 Noon

**Session chair:** Jillian Bellovary

#### **Agenda**

- **LIGO O3 Results Summary [PDF]** – Evan Goetz (15 mins, 5 questions)
- **NANOGrAV Results Summary [PDF]** – Scott Ransom (15 mins, 5 questions)
- **LISA Overview of Science and Programmatics [PDF]** – Ira Thorpe (15 mins, 5 questions)
- **BlackHoles@Home [PDF]** – Zach Etienne (15 mins, 5 questions)

# the Inflation-Probe Science Interest Group highlights and updates



## ☐ IP SIG

- Organized session at virtual January AAS

### Inflation Probe SIG

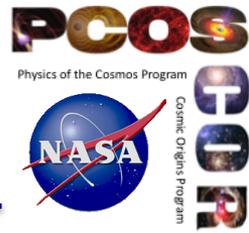
Wednesday, 13 January 2021, 12:00 Noon

**Chair:** Kevin Huffenberger

### Agenda

- **IPSIG Overview** [[PDF](#)] – Graça Rocha, JPL/Caltech (15 + 5 mins)
- **PICO Overview** [[PDF](#)] – Shaul Hanany, University of Minnesota (15 + 5 mins)
- **CMB-S4 Overview** [[PDF](#)] – Julian Borrill, LBL (15 + 5 mins)
- **Complementarity of Space and Ground-based Experiments** [[PDF](#)] – Charles Lawrence, JPL (15 + 5 mins)
- **Discussion** (10 mins)

# the Cosmic Structure Science Interest Group highlights and updates



## ☐ CoS SIG

- Organized session at virtual January AAS

## Cosmic Structure SIG

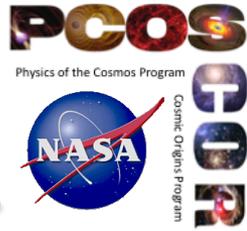
Thursday, 14 January 2021, 4:10 P.M.

## Agenda

- **Overview of Cosmic Structure SIG** – James Rhoads, NASA/GSFC (15 mins)
- **The Interplay between Space- and Ground-Based Baryon Acoustic Oscillation Studies** [[PDF](#)] – Donghui Jeong, Penn State Univ. (15 mins)
- **The ODIN Survey: Hunting for the Largest Cosmic Structures in the Distant Universe** [[PDF](#)] – Kyoungsoo Lee, Purdue University (15 mins)
- **Cosmological Simulations of Galaxy Formation: A Multi-Scale Effort** [[PDF](#)] – Jorge Moreno Soto, Pomona College (15 mins)
- **Discussion** (30 mins)

# Science Interest Group highlights and updates

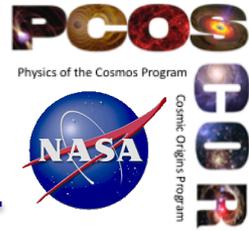
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## ☐ IP SIG and CoSSIG

- IPSIG and CoSSIG note there was a [joint NASA/DOE RFI on High Energy Physics and Space-Based Astrophysics](#), and there were many responses with areas relevant to IPSIG and COSSIG, and broad community interest.

# the X-ray Science Interest Group highlights and updates



## ☐ X-Ray SIG

- Organized session on X-ray Explorer missions at virtual January AAS
- Planning session on X-ray astrophysical constraints on fundamental physics for April APS

### X-Ray SIG

Wednesday, 13 January 2021, 6:50 P.M.

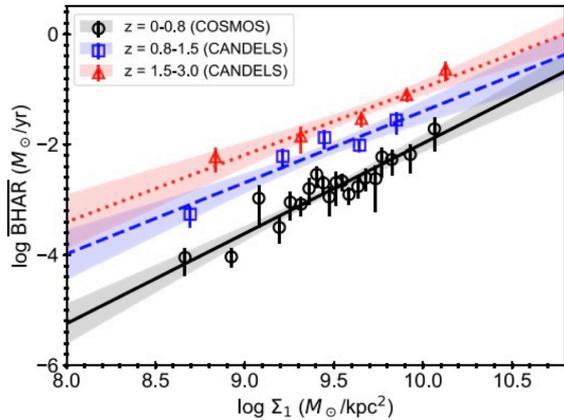
Chair: Grant Tremblay

### Agenda

- **Introduction** [PDF]
- **Science with Ongoing Explorer Missions**
  - **Gehrels/Swift** [PDF] – Jamie Kennea, Penn State (20 mins)
  - **The NuSTAR mission and Science Highlights from 2020** [PDF] – Kristin Madsen, CRESST and X-ray Astrophysics Laboratory, GSFC (20 mins)
  - **NICER** [PDF] – Erin Kara, MIT (20 mins)
- **Status of Upcoming Explorer Missions**
  - **IXPE** – Martin Weisskopf, MSFC (10 mins)
  - **Status Report on the X-ray Imaging and Spectroscopy Mission (XRISM)** [PDF] – Brian Williams, GSFC (10 mins)

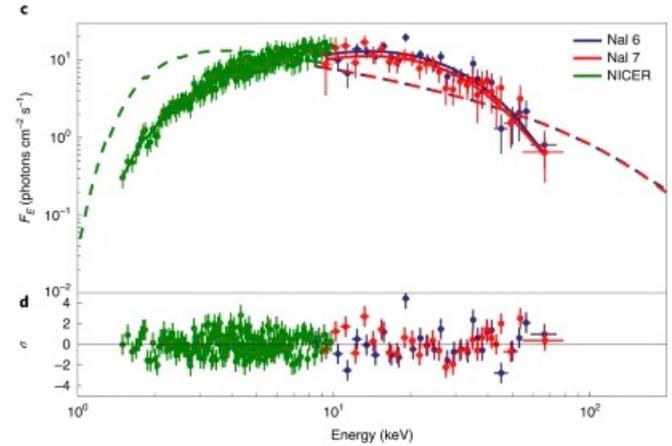
# the X-ray Science Interest Group highlights and updates

## Some X-ray science highlights



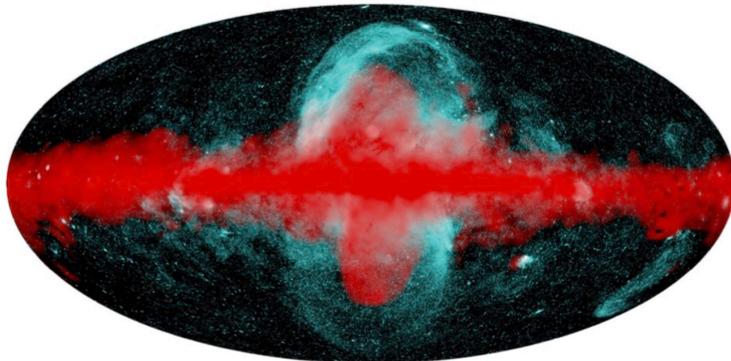
Chandra: Ni et al. (2021)

X-ray emission from a magnetar fast radio burst



NICER: Younes et al. (2021)

Connection between black hole growth and host galaxy compactness.

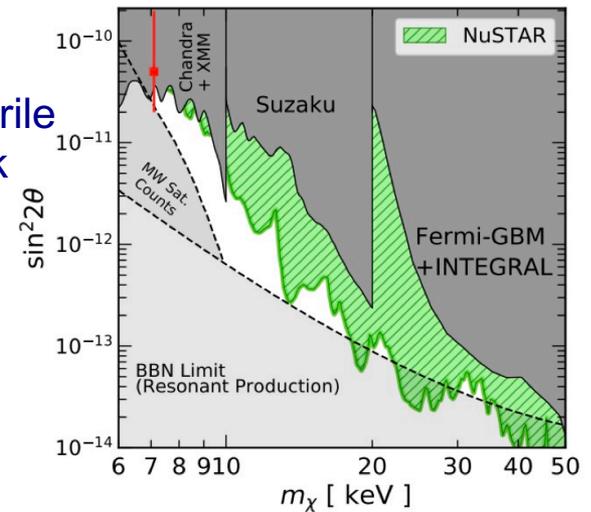


eROSITA: Predehl et al. (2020)

Ryan Hickox, 16 March 2021

Limits on sterile neutrino dark energy

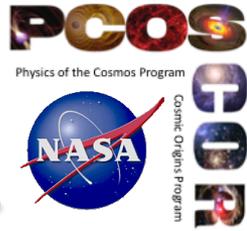
Large-Scale X-ray Bubbles in the Milky Way



NuSTAR: Roach et al. (2020)

# Cross-PAG Efforts on Cross-Cutting Technologies and Data Analysis Frameworks

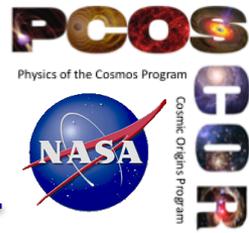
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- PhysPAG has continued discussions on potential cross-PAG initiatives on **cross-cutting technologies** and **data analysis frameworks**.
- Consensus is that these efforts will be most effective after the publication of the Astro2020 Decadal Survey results.
- Potential SAGs and corresponding Terms of Reference are being discussed.

# Cross-PAG Effort on Participation in NASA Astrophysics

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- Currently led by Jillian Bellovary (XRSIG and GWSIG Co-Chair) with members from PhysPAG, COPAG, and ExoPAG

Organized successful session at AAS (~80 participants):

**Introduction** (organizers) (5 mins)



**Diversity, Equity, and Inclusion in Space Science: The Sustainable Picture** Dara Norman, NSF's NOIRLab (15+5 mins)



**NASA Astrophysics at an HBCU: University of the Virgin Islands** David Morris, UVI (15+5 mins)



**Space Science at MSIs: A Student's Perspective**  
Tenley Hutchinson-Smith, UCSC/Spelman College (15+5 mins)

**Panel discussion** (25 mins)

# Proposed Science Analysis Group

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- Draft **Terms of Reference** for a Multi-PAG SAG have been put together by this group. These will be refined with input from colleagues with a broad range of backgrounds and expertise.
- Goals are to:
  - Identify institutions (“under-resourced institutions”) that face barriers to participation in NASA astrophysics, with a particular focus on barriers arising from systemic exclusion.
  - Work with existing organizations to aggregate extant data that quantify the known barriers that limit access to NASA research and training at these institutions for faculty, students, and research scientists.
  - Analyze the efficacy of existing NASA programs, including MUREP, for their efficacy in reducing these barriers.
  - Obtain as complete as possible a picture of the needs, wishes, and obstacles faced by faculty, scientists, and students at under-resourced institutions, and analyze this input to understand the potential impact of possible initiatives to reduce barriers to participation.

# PhysPAG/SIG Meetings and Activities

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- **April APS, April 2021, Virtual**
  - Will have **five SIG sessions** plus **one Town Hall**
- **Summer AAS, June 2021, Virtual**
  - Gamma Ray SIG session
- **Regular meetings of PhysPAG EC, SIGs, and organization of potential SAGs**