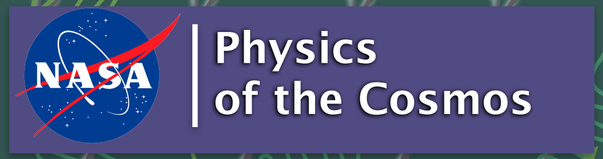

Future Innovations in Gamma Rays
A New Science Analysis Group

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Physics of the Cosmos
APS April 2024
Mini Symposium
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FIGSAG Background and Motivation

- Science Analysis Group (SAG) Reports help to inform NASA about specific topics and the community's priorities in between and leading into Decadal Reports.
- FIGSAG formed to formally study the science drivers, necessary capabilities, and prioritize the future study of gamma-ray astronomy
- We hope to organize and describe the strategic science cases, technology gaps, and threshold mission capabilities for a new generation of gamma-ray missions
- We intend to prioritize gamma-ray science cases along the lines of baselines of observables

Scope of Work Highlights

- Gamma-Ray Science Priorities
  - How can future gamma-ray observations advance our current understanding?
  - What are the observational capabilities and requirements for these future studies?
- Theory / Modeling / Analysis / Fundamental Physics Needs
- Technology Investment
- Gamma-Ray Mission Capabilities
- Synergies with Other Programs

Defining the Gamma-Ray Identity

- It is strategically important to define gamma-ray science in terms of gamma-ray science
  - There has been a focus in recent years on defining gamma-ray science in terms of multimessenger science
  - Prior, there was a focus on defining gamma-ray science in terms of multiwavelength studies.
  - However, we risk the message other folks hear to be - ‘our only importance is in how well we support other subfields’
- However, we should not expect that any mission will be funded primarily due to its ability to support other facilities.
  - Strategically, gamma-ray missions should first support gamma-ray science and we need to develop the arguments and messaging for this.

Monthly Virtual Meetings

- Prior to meetings
  - we email the listserv with the topic information
  - Post topical surveys on Slack & Start the Channel discussion
  - Prepare discussion topics, open questions, breakout areas
- During meetings
  - We usually spend 90 min total
  - Openning plenary provides the topic of the day and some context
  - Breakout rooms allow for more in-depth discussions
  - Closing plenary brings together highlights
  - Plenaries are recorded and Breakout rooms have notes taken

Overview of Science Priorities Discussion

- Nature of Dark Matter/Dark Energy
  - pin down the 511 keV; reaching the thermal relic line; Galactic Center Excess measurements limited by Fermi's angular resolution; Improvements in PSF, energy resolutions; feasibility of GeV polarization to help identify ALPs
- Formation and Merging of Supermassive Black Holes
- Origins of Heavy Elements in our Galaxy
  - nuclear line datasets; angular resolution.
- Sources of Cosmic Ray Accelerations
  - MeV gap; proton transport; energy and imaging resolution, polarization, and high-precision timing
- Existence of Life in Our Galaxy
  - techno signatures, biological signatures; nuclear weapon activity

Overview of Theory & Simulations Discussion

- Plasma Physics Theory & Modeling (Standard Model Physics)
  - PIC codes, MHD codes, hybrid models. Current models insufficient to explain time-dependent data. Insuffiecinet timing data on AGN/magnetars
- Nuclear Modeling & Simulations (Cross sections & Lines)
  - combined atomic and nuclear model; Gaps in nuclear physics; 511 annihilation line; Different nuclear networks get different yields; map from HPC to a phenomenological model; AI for gamma-spectra
- Data Analysis & Simulation Methods
  - Challenges in Multimission analysis; GRBs - connecting observational signatures with physical models.
- Particle Physics Modeling & Simulations (Beyond Standard Model)
  - GC excess is tested against rudimentary models of DM; better astrophysical understanding; background worries

June Workshop

- June 24-28 at Michigan Tech
  - Preregistration is open now - visit our website to fill out the form https://pcos.gsfc.nasa.gov/sags/figsag/events/workshops/June-2024/June-2024.php
  - Abstracts due by Apr 30; Travel intention appreciated by Apr 15
- Plenary sessions Mon & Fri
  - Overall strategy, messaging, complementarity with current missions and future facilities in other bands/messengers
- Parallel sessions Tues, Wed, Thur
  - Talks & discussion to help develop the arguments for science priorities and baseline cases for categories of observable

Science Traceability Matrix

1	2	3	4	5	6	7	8
Science Goals	Science Objectives	Scientific Measurement Requirements: Observables	Scientific Measurement Requirements: Physical parameters	Instrument Performance Requirements		Projected Instrument Performance	Mission Requirements (Top Level)
Goal 1		Absorption line	Column density of absorber	Alt. Range	XX km	ZZ km	Observing strategies: requires yaw and elevation maneuvers
Goal 2		Emission line	Density and temperature of emitter				Launch window: to meet nadir and limb overlap requirement. Window applies day to day
Etc.	Objective 1		Size of features	Vert. Resol.	XX km	ZZ km	Need AA seasons to trace evolution of phenomena

https://smd-cms.nasa.gov/wp-content/uploads/2023/04/Launchpad_Session3_STM_18Nov2019_smf_final.pdf

Preliminary Strategic Framework (STM)

- Timing & effective area
  - GRBs ~100ms; Magnetars / Pulsars, time a millisecond pulsar ~ms; flux, photon arrival time; localization
- Spectral resolution
  - gamma ray lines; DM / ALPs, CR, LIV; lensing of GRBs against compact objects; Need to develop threshold cases; Doppler shifts of lines can break degeneracies in distances in other galaxies
- Polarization
  - MDP per flux, energy range; AGN, Magnetars / Pulsars, GRBs; Sensitivity to get better time resolution on polarization measurements for variable sources
- Atomic / Nuclear / particle physics decay
  - Counterpart to nonthermal particle acceleration, decay; Bottlenecks of not quite knowing which process causes observed emission

Report Organization

- Overview
  - Status Quo, context of current gamma-ray missions & facilities
- Primary Baseline Science Cases
  - Details about the science and required sensitivity, etc
- Secondary and tertiary Baseline Science Cases
  - Details about science cases that require slightly less sensitivity, etc
  - What science cases can be accomplished per observable requirement?
- Complementarity
  - Gamma rays first messaging, but also broader context of multiwavelength and mutlimessenger

Synergies as Secondary

- While synnergies are secondary in terms of mesaging, they are a full section of the report on their own. How can future gamma-ray missions
  - complement the fleet of NASA missions
  - multi-messenger astronomy
  - ground-based facilities
- Are there key facilities that set necessary timelines for future gamma-ray missions?
- What synergies exist with other agencies?
  - efforts in detector technology, electronics research and development, data analysis techniques, laboratory astrophysics, modeling methods, software, data archiving?

Messaging

- Developing cohesive messaging around gamma-ray science
  - We want members of the gamma-ray community to be able to articulate a similar message about what we want as a field
  - So, we then have to identify what that message could be - to funding agencies, to the public, to Congress, to other subfields
- Developing Materials around messaging
  - Working with the artists who made the exoplanet vacation poster series
  - Struggling with the message behind the medium
  - Maybe baseline science cases (as vacation destinations?)

How to Join & Contribute

- Website
  - https://pcos.gsfc.nasa.gov/sags/figsag.php
  - Join our mailing list (have a sticker)
  - Join our slack space
- Virtual Meetings
  - Join the Discussion
- Michigan Tech Workshop
  - Preregistration is open now
  - Abstracts for parallel (and plenary) talks
  - Conference Proceedings - details TBD

FIG SAG

Future Innovations in Gamma Rays

We will explore gamma-ray science priorities, necessary capabilities, new technologies, and theory needs to inspire work toward 2040.

Get involved and stay informed:
https://forms.gle/VBijBgapMRwJm9dU6

Chairs:
Chris Fryer & Michelle Hui, Paolo Coppi, Milena Crnogorčević, Tiffany Lewis, Marcos Santander, and Zorawar Wadiasingh

Questions?