Meeting 2: Theory and Analysis Needs

Document Structure:
- General Information & Resources
- Science Topics Summaries:

General Information & Resources

Date & Time: February 29, 2026, 1 PM GMT-5, Zoom.
Presentation Slides: Theory & Analysis Needs
Video recording: video1328845424.mp4
Timeline of the Video recording:
0:00 – 8:30: Welcome & Introduction to FIG SAG
8:30 - 25:00 General Discussion
25:00-1:03:00 Breakout session (session 1 recorded)
1:03:00-1:21:00 Outbriefs
1:21:00-1:26:00 Final thoughts

Breakout Summaries

Plasma Physics:

Link to notes: Breakout Room 1 Notes: Plasma Physics

Summary: In this session we discussed different types of phenomena:ets from different objects: e.g. blazars, magnetars, …

We also discussed how to integrate models at the small scale simulations (like particle-in-cell calculations) into the large-scale simulations of astrophysical phenomena. Phenomenological models tend to simplify the physics seen in the detailed kinetic calculations. Is there a way to better include those details in comparisons to data. (A note on this: LANL is hosting a 5 week meeting on scale-bridging April 22-May 24). Can AI speed up the development of models to couple this physics?

We also discussed what data is needed to inform those models: e.g. polarization, multi-messenger data, timing data. We discussed the differences in the way that GRB and AGN communities talk about data analysis in time-domain. Finally, we discussed what specifically do we need from the data to help better inform the models. We felt that having more time resolution would help those models.

Nuclear Physics:

Link to notes: Breakout Room 2 Notes: Nuclear Physics

Summary: This session focused on the advances in nuclear physics and a discussion on what we need to do to tie nuclear physics to observations.

Nuclear physics is making a broad range of improvements in the nuclear cross-sections. The nuclear astrophysics community is coupling these results into their studies. But there is relatively less work done on astrophysically-relevant isomers (a.k.a. astromers). There may be significant advances that can occur by studying these in more detail.

For much of what we study, the connection between nuclear and atomic physics is important. This field also could benefit from further study.

There are a large number of numerical studies that are needed to calculate the observables: we need to improve our uncertainty quantification of our nuclear networks (this is most important for rare elements). How do we couple the high-performance computing calculations to the data. We need to develop more detailed studies of our calculations to tease out trends from the calculations (perhaps AI could help with this). We also discussed AI in the context of analyzing spectra.

Can we leverage detector technology in nuclear experiment to improve our dectectors?

Data Analysis:

Link to notes: Breakout Room 3 Notes: Data Analysis

Identified challenges on multiple levels within data mining. As we start to look at broader sets of data including different messengers (e.g. compton, polarization), we will have to review the techniques, especially statistical or AI techniques to ensure accuracy. Among these is to make study the effects of different data formats and analysis frameworks (which can change the way results are interpreted).   Some emerging frameworks that address this that allow more statistical studies. We want to understand the software limitations of this analysis. The analysis of compton data may require a completely different analysis from polarization or other data. This will be important for all statistical analyses including AI/ML.

Can we pursue consistency across the models? For example, AGN and GRB jets arise from the same physics, but there are very different timescales. How do we allow models to leverage this data to develop a model that will in turn guide analysis needs. How do we interpret data from multiple missions with different sensitivities or uncertainties.

Data Analysis:

Link to notes: Breakout Room 4 Notes: particle physics

We had a lot of discussion about current observations and issues.

For many cases, e.g. the Galactic center excess, the current studies tend to compare to rudimentary models. There needs to be more interaction between the observer and theory community to do more detailed models.   Another issue is an understanding of the astrophysical sources. We still need better justification and modeling for these sources (e.g. pulsars, PWN) because these will add to the astrophysical background. Another modeling problem that enters: the level of signals we're searching for are week. In addition we need a better understanding of the background and foreground components, also need to worry about non-astrophysical aspects like instrumental backgrounds, calibration, etc to some accuracy that needs to be specified. To make a best case of our sources, we need to better understand what sensitivities we need to achieve to probe particle physics.   A theory study that provides the needed sensitivities would strengthen our case for instrumentation. We also discussed what new physics we could study by looking at a broader set of astrophysical phenomena. AI and ML could play an important role, but we must understand its limitations.