



Snowmass 2021 CF7

**Cosmic Probes of Fundamental Physics
(Beyond the Standard Model and Dark Matter)**

Ling Sun on behalf of CF7 WP5 authors

**Leading authors: S. Chakrabarti, S. Clesse, C. Dvorkin, J. Garcia-Bellido, J. Meyers, A. Miller, S. Shandera, L. Sun
Check Point Meeting, Feb 3, 2022**

Topics

Cosmic Probes of Fundamental Physics (Beyond the Standard Model and Dark Matter)

- Using gravitational wave interferometers as particle detectors to directly probe dark matter ([CF#072](#))
 - Andrew Miller andrew.miller@uclouvain.be
- Search for gravitational waves from ultralight boson clouds around black holes ([CF#136](#))
 - Ling Sun ling.sun@anu.edu.au
- Gravitational waves from primordial black holes ([CF#091](#))
 - Sebastien Clesse sebastien.clesse@ulb.be, Juan Garcia-Bellido juan.garciabellido@uam.es
- Gravitational wave observations as a probe of dissipative dark matter ([CF#228](#))
 - Sarah Shandera ses47@psu.edu
- Novel dynamical probes of dark matter on small scales ([CF#014](#))
 - Sukanya Chakrabarti chakrabarti@astro.rit.edu
- Insights for fundamental physics and cosmology with light relics ([CF#147](#))
 - Joel Meyers jrmeyers@smu.edu, Cora Dvorkin cdvorkin@g.harvard.edu

Status

Cosmic Probes of Fundamental Physics (Beyond the Standard Model and Dark Matter)

- **Summary of the status**

- Weekly/bi-weekly meetings among the leading authors
- A high-level draft of the WP is available in the overleaf link
- The content remains to be fleshed out; structure needs to be further adjusted
- Overlap with other WPs and gaps in the topics need to be identified and discussed
- Suggestions regarding the perspective and the structure of this WP are appreciated

- **Timeline & plan (with challenges)**

- Dec 2021: started the WP
- Jan 1-15, 2022: discuss the structure and coordination/draft the key messages & skeleton
- Jan 15-Feb 15, 2022: working on individual sections; start to share the document more widely and invite more people to contribute
- Feb 15-28, 2022: Iterate on the whole paper and Executive summary; work with more contributors; address overlaps, gaps, and cross references
- Mar 1-15, 2022: address comments and cross references; aim to produce a mature version

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Structure

Cosmic Probes of Fundamental Physics (Beyond the Standard Model and Dark Matter)

- The **key perspective** of this WP:
 - Our current understanding of dark matter comes from direct and indirect observations from the distribution of gravitating matter on large scales and from measurements of the total matter content in the universe.
 - We lay out the case for **small-scale structure and compact objects as dark matter probes**, using various approaches. Coordination of the communities studying GWs, compact objects and astrometry and those studying dark matter is required. (Thinking of a diagram that combines all these aspects.)
- Describe the science cases that can be enabled in the next decade and the expected outcomes in the **Executive Summary**

Section 2

2	Background and motivation	3
2.1	Probes of ultra-small-scale structure	3
2.2	Observational enablers	3

- Leading author(s): Sarah Shandera, Sukanya Chakrabarti
- Provide an overview of the background, motivation, and a high-level summary of the science cases.
- Some introductory information will be given here, e.g., target sources, beyond-SM particles.
- New observational facilities — cross reference to the facility WPs
- Take into consideration the overlap between CFs.

Section 3

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3.3	Ultralight bosons and black hole superradiance	6
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- Leading author(s): Sarah Shandera, Sebastien Clesse, Juan Garcia-Bellido, Ling Sun
- Each subsection covers one cosmic approach
- Collaborated with CF3 WP coordinator/contributor(s) on the superradiance section — mainly have theories and spin measurements in CF3 while GW-related probes in CF7, and a summary of everything on both sides; there might also be overlap with the fundamental physics WP in CF7

Section 4

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4.4	Searches	11
4.5	Prospects	12

- Leading author(s): Andrew Miller
- Different from the previous section — directly using GW detectors as DM detectors
- Some of the introductory information will be moved to the background and motivation section.

Section 5

5	Complementary and integrated probes of total matter content of the universe	13
5.1	Light relics	13
5.2	Neutrino mass constraints	14

- Leading author(s): Joel Meyers, Cora Dvorkin
- Complementary and integrated approaches are described in this section.

Questions & Discussion