CF1. Dark Matter: Particle-Like Kick-off Meeting

Co-Conveners: Jodi Cooley (SMU), Tongyan Lin (UCSD), Hugh Lippincott (UCSB), and Tracy Slatyer (MIT)

Agenda

- Process / Scope of Work (Jodi)
  - Organization/How to Get Connected
  - Timeline
  - Letters of Interest
  - Scope of this topical group
  - Synergies with other groups
- Frameworks for future discussion (Tongyan, Tracy)
  - Direct Detection Landscape
  - Indirect Detection Landscape
- Final Thoughts (Hugh)

The Snowmass Process - https://snowmass21.org

Goal: Organized by the Division of Particles and Fields (DPF) of the American Physical Society (APS), this process is intended to **define the most important questions** for the particle physics community and to **identify the most promising ways to address these questions** in a global context. Snowmass provides an opportunity for the entire HEP community to come together to **identify and document a vision for the future of particle physics in the US and its international partners.**

Organization: **Snowmass 21 ⊃ Cosmic Frontier (CF) ⊃ topical group CF1 = Dark Matter: Particle-Like**

- Get Connected:
  - Fill out the interest form: https://forms.gle/MmMMJDN4PCAARcwn8
  - Join the Slack channel (CF-01): https://app.slack.com/client/TNNU4A570/C0136B7F8MN/details?cdn_fallback=2
  - Join the email list (CF-01): SNOWMASS-CF-01-DM-PARTICLE@FNAL.GOV
- Resources:
  - Snowmass Virtual Town Hall presentations/recordings: https://indico.fnal.gov/event/23601/
  - Indico master site for Snowmass-related meetings: https://indico.fnal.gov/category/1098/

The Snowmass Timeline

- **ASAP: fill out the interest form today (https://forms.gle/MmMMJDN4PCAARcwn8)**
- **August 31, 2020: deadline for letters of interest (https://snowmass21.org/loi)**
- **November 4-6, 2020: Snowmass Planning Meeting (Fermilab)**
- **July 11-20, 2021: Snowmass Summer Study (UW Seattle)**
- **July 31, 2021: deadline for submitted papers (https://snowmass21.org/submissions/start)**
- **End of 2021: final Snowmass 2021 report**

Letters of interest (first deadline, end of August):

- Up to 2 pages (not including bibliography)
- Should give brief descriptions of the proposal and cite the relevant papers to study
- Inputs to Snowmass Planning Meeting (November 2020), allow conveners to see what proposals are coming and to encourage the community to begin studying them

Goal of this topical group “CF1: Dark Matter: Particle-Like”

This group covers dark matter in the regime where it appears in experiments as individual quanta, rather than coherently via wave phenomena. Techniques to search for such particles include directly through its interaction with detector materials, indirectly from products of its annihilation, and via production at accelerators (primarily covered in other frontiers).

- ➢ Distinguished from CF2 (Dark Matter: Wave-like) by focus on higher mass range (roughly ~1 eV and above)
- ➢ Distinguished from CF3 (Dark Matter: Cosmic Probes) by focus on particle signals of DM: CF1 covers (among other topics) classic indirect-detection searches for the particle products of DM annihilation/decay, but CF3 contains a broader range of astrophysical/cosmological probes

Synergies with the rest of Snowmass

Some are already clear (more may develop!)

- Theory Frontier: **TF08** - BSM Model Building, **TF09** - Astro-particle physics and cosmology
- Energy Frontier: **EF10** - Dark Matter at Colliders
- Frontiers in Neutrino Physics: **NF02** - Sterile Neutrinos, **NF03** - BSM
- Rare Processes and Precision Measurements: **RF06** - Dark Sector Studies at Low Energy
- Accelerator Frontier: **AF05** - Accelerators for PBC and Rare Processes
- Broad overlap with Instrumentation and Computational Frontiers & Underground Facilities
- Within the Cosmic Frontier:
  - CF2: Dark Matter - Wave-like
  - CF3: Dark Matter - Cosmic Probes

(Preliminary) Direct Detection Landscape

Gaseous + directional: NEWS, CYGNUS
Bubble chambers: PICO
Noble-liquid: Xe-based, Ar-based, He-based
Superfluid He
Solid state: Insulators, semiconductors, polar crystals, dirac materials, superconductors, etc
Molecules: Resonant absorption, magnets, organic scintillator

† Directional detection may be possible

Signal classes \ Model classes	Heavy DM* (> TeV)	Weak-scale DM, classic WIMPs*	Higgs portal mediated models*	Dark photon mediated models*	Scalar mediator (nucleons)*	Scalar mediator (electrons)*	Bosonic DM absorption (Dark photons, ALPs, scalars, sub-keV)
SI nuclear recoils w/ rates down to the neutrino floor for > 10 GeV DM	Noble-liquid	Noble-liquid	Noble-liquid	Noble-liquid	Noble-liquid		
SI nuclear recoils w/ rates down to the neutrino floor for 1-10 GeV DM		Gaseous† Bubble chamb. Noble-liquid Solid state	Gaseous† Bubble chamb. Noble-liquid Solid state	Gaseous† Bubble chamb. Noble-liquid Solid state	Gaseous† Bubble chamb. Noble-liquid Solid state		
Spin-dependent (SD) nuclear recoils	Bubble chamb. Noble-liquid	Gaseous† Bubble chamb. Noble-liquid					
SI nuclear recoils from sub-GeV DM			Solid state† Superfluid He	Solid state† Superfluid He	Solid state† Superfluid He		
Electron recoils	Noble-liquid	Noble-liquid		Noble-liquid Solid state† Molecules		Noble-liquid Solid state† Molecules	Noble-liquid Solid state† Molecules
Collective excitations (molecules, phonons, plasmon, etc)				Solid state† Molecules	Solid state† Superfluid He Molecules	Solid state† Superfluid He	Solid state Molecules

* Relic abundance could be set by freeze-out, freeze-out, asymmetry, freeze-in, SIMP/ELDER mechanisms (MeV-GeV masses), etc.
Signals may differ for inelastic splittings, strongly-interacting cross sections, up-scattered/accelerated DM, etc.

Indirect Detection Landscape (rough first pass!)

bold=upcoming/proposed

	Ultraheavy DM	GeV-TeV classic WIMPs/SUSY	MeV-GeV dark sectors	Sterile neutrinos / warm DM	Millicharged DM	Freeze-in models	Boosted DM	eV+ light scalars	eV+ hidden photons	Primordial black holes
TeV+ neutrinos (ICECUBE, ANTARES, ANITA, **Km3Net**)	x	x					x			
MeV-TeV neutrinos (SuperK, **HyperK**, **DUNE**)							x			
TeV+ cosmic rays (Auger, TA)	x									
GeV-TeV CRs (AMS-02, DAMPE, CALET)		x								
Sub-GeV CRs (**GAPS**)		x	x							
TeV+ gamma rays (HAWC, VERITAS, HESS, LHAASO, **CTA**)	x	x								
GeV-TeV gamma rays (Fermi, **GAMMA-400**, **HERD**)	x	x								
~MeV-GeV gamma rays (INTEGRAL, **AMEGO, e-ASTROGAM**, **PANGU**)			x							x
X-rays (e.g. XMM-Newton, Chandra, NuSTAR, eROSITA, **Micro-X, Strobe-X, XRISM, ATHENA, LYNX**)		x	x	x				x	x	
Microwave/CMB (e.g. Planck, ACT, SPT, BICEP, **Simons Observatory, PIXIE, CMB-S4**)		x	x		x	x			x	x
Radio (e.g. MeerKat, PAPER, HERA, CHIME, EDGES, **LEDA**, **DARE**, **SKA**)		x	x		x					
BBN observations			x	x	x			x	x	

Summary and next steps

- Please fill out the interest form -- we will use the results to start planning topical group meetings for the rest of the year.
- We want to ensure we have a comprehensive view of the direct and indirect landscape.
- We are aware of topical overlaps, and want to make sure nothing gets lost in the cracks.

➢ Reminder of ways to get connected:

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