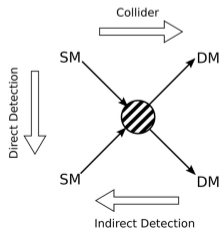# DarkBit/CosmoBit update and discussion
GAMBIT 16

dm-cosmo working group

2024-09-18+16:30 (GMT+2)

GAMBIT 16: DarkBit/CosmoBit Update & Discussion

Useful Links:

- ▶ GAMBIT wiki: github.com/GambitBSM/wiki
- ▶ Schedule: agenda.infn.it/event/41823
- ▶ Minutes:
  github.com/GambitBSM/wiki/blob/main/meetings/DarkBit_CosmoBit_meetings.md
- ▶ Overleaf: overleaf.com/9939795564qqfsskmzcrgn#2d2026

  These slides were written with the aid of GPT-4, derived from the meeting minutes. Please correct any errors on the overleaf

Active members

Those that have been minuted at a call this year (obviously a significant systematic timezone related bias):

▶ **Regular Attendees**:
  ▶ Will Handley
  ▶ Aaron Vincent
  ▶ Felix Kahlhoefer
  ▶ Csaba Balazs
  ▶ Tomas Gonzalo
  ▶ Martin White
  ▶ Jonathan Cornell
  ▶ Anders Kvellestad
  ▶ Torsten Bringmann
  ▶ Chris Chang

▶ **Occasional Attendees**:
  ▶ Sebastian Hoof
  ▶ Timon Emken
  ▶ Bill Loizos
  ▶ Xuan-Gong Wang
  ▶ Lukas Hergt
  ▶ Ankit Beniwal
  ▶ Andre Scaffidi

What does DarkBit/CosmoBit do?

- CosmoBit
  - Interface between GAMBIT and cosmology theory/data
  - Mostly via MontePython
  - Effect on cosmological evolution (CMB/WL etc)
  - X/γ-ray telescope/Supernovae detecting DM decay
- DarkBit
  - Direct detection
  - Collider bounds on models
- At the join primarily are:
  - Particle physics models of Dark Matter
  - Neutrinos
  - ...

Collider

SM   DM

Direct Detection

SM   DM

Indirect Detection

Cosmology News and Updates
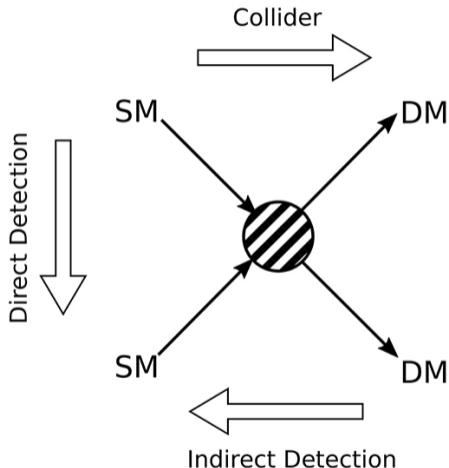
- **Hubble Tension Update**:
    - CMB says $H_0 = 67.4 \pm 0.5$ km/s/Mpc
    - Local measurements say $H_0 = 73 \pm 1$ km/s/Mpc
    - Wendy Freedman recently presented Hubble measurements using JWST data.
    - Results show calibration discrepancies: Cepheids (73 ± 1), TRGB (70 ± 1), JAGB (67 ± 1), Planck (67.4 ± 0.5). Adam Riess re-did the analysis, and it comes back to 73 ± 1
    - This does not cover the SN community in glory.
- **DESY5 Supernovae**:
    - DESY5 + DESI results give non-trivial w0, wa constraints.
    - Some criticism from the DESI side but ongoing discussions.
- **DESI Data**:
    - Released Year 1 data and likelihoods.
    - Discussed potential projects related to neutrino masses and dark energy models.

Dark Matter News and Updates

- ▶ **New Collaborations and Contributions**:
    - ▶ Potential collaboration with Munich's "dark matter data center".
    - ▶ Knut Mora from XENON collaboration implementing new XENON1T likelihood in DDCalc.
- ▶ **Publications and Submissions**:
    - ▶ SubGeV paper submitted to JCAP.
    - ▶ Several internal reviews and ongoing projects nearing publication.
- ▶ **Conferences and Workshops**:
    - ▶ Active participation in various conferences and workshops.
    - ▶ Aaron Vincent is a DM convener for an upcoming workshop.
- ▶ **New Tools and Methods**:
    - ▶ New method for optimizing direct detection constraints by Giorgio.
    - ▶ Implementing interpolation functions for x-ray constraints within DarkBit.
- ▶ **EDM (Electric Dipole Moment)**:
    - ▶ Literature review and planning phase.
    - ▶ Reproduction of SFitter results underway.
    - ▶ Flavio backend integration in progress.
    - ▶ Hannah leading the work with Jacinda, Martin, Are, Peter, and Anders involved.

Ongoing Projects (in inverse order of nearliest donelieness)

▶ SubGeV Dark Matter [under review]
▶ Annual Modulation [nearly done]
▶ EDM [nearly done]
▶ GravBit [nascent]
▶ DESI Data [not started]

SubGeV Dark Matter: Progress and Next Steps

- **Progress**:
  - SubGeV paper submitted to JCAP. [2405.17548]
  - Will gave a talk at this at a Cambridge astro DM meeting: `willhandley.co.uk/talks`
- **Next Steps**:
  - Await reviewer

Annual Modulation

▶ **Progress**:
  ▶ Implemented and tested new COSINE likelihood.
  ▶ Frequentist and Bayesian scans conducted.
  ▶ Results indicate DAMA is inconsistent with RATE but might be consistent with COSINE.
  ▶ Debugged convergence issues in frequentist scans.
  ▶ Latest COSINE and ANAIS data indicate that DAMA is almost certainly not consistent with any of the other experiments.
  ▶ Martin and Will discussed what to run
     [AM, DAMA, AM+DAMA, AM+RATE]×[universal, energy independent, hybrid]

▶ **Next Steps**:
  ▶ Finalise new likelihoods [Jonathan has implemented, but not fully debugged]
  ▶ Re-run scans.
  ▶ Write paper
  ▶ This is time sensitive. There will be community interest in doing a proper statistical "how wrong is DAMA", but not for long.

EDM (Electric Dipole Moment): Progress and Next Steps

▶ **Progress**:
  ▶ Literature review and planning phase.
  ▶ Reproduction of SFitter results underway.
  ▶ Flavio backend integration in progress.
  ▶ Hannah leading the work with Jacinda, Martin, Are, Peter, and Anders involved.

▶ **Next Steps**:
  ▶ Code up new EDM likelihoods.
  ▶ Conduct global fits in weak effective theory.
  ▶ Examine future projections and improvements.

GravBit: Progress and Next Steps

▶ **Progress**:
  ▶ Initial discussions on unique contributions.
  ▶ PTArcade backend implemented for PTA data.
  ▶ Identified potential for first-order phase transitions observable with gravitational waves in sub-GeV dark matter models.
  ▶ Felix interfacing Carlo's code for phase transition calculations with PTArcade.
  ▶ Csaba's group developing PhaseTracer2 for end-to-end gravitational wave spectrum calculations.

▶ **Next Steps**:
  ▶ Define clear project goals.
  ▶ Explore joint fits using inflationary constraints.
  ▶ Integrate with CosmoBit and DarkBit.
  ▶ Prepare a spin-off paper from the sub-GeV dark matter project, demonstrating the power of GravBit.
  ▶ Possible short-author paper focusing on contributors to the sub-GeV DM project.

DESI Data: Progress and Next Steps

- **Progress**:
  - Released Year 1 data and likelihoods.
  - Discussed potential projects related to neutrino masses and dark energy models.
- **Next Steps**:
  - Evaluate science cases for neutrino masses and dark energy models.
  - Discuss Cobaya interface.

DiRAC 15th call

▶ Halfway through our allocation (ends March 2026)
▶ Making good usage (now having to manage not using it all
▶ Will put in a speculative renewal application for this call last week.
▶ If this fails, we will need to coordinate for a more careful application for the next call
  (Deadline September 2025), which may be close to the next GAMBIT meeting.

Possible discussion points

► Meeting frequency/timing?
  ► We have a near maximally awkward set of European/Canadian/Australian timezones to contend with.
► Next stage projects to drive backend development (e.g. GW, 21cm, DESI)
► Adil COSMICS work

This was an image generated from this prompt to DALL.E 3:

"Generate an image that represents the collaborative research efforts in dark matter and cosmology. The scene should include scientists working together, advanced computer simulations, and visualizations of dark matter particles, cosmological phenomena like the cosmic microwave background, and gravitational waves. Include elements that suggest data analysis, such as graphs and equations, and a backdrop of a starry night sky or a futuristic lab setting."

which in turn was generated by GPT-4 from the conversation which helped write these slides.