ENIGMASS - WP3

Dark matter and dark energy or the standard model of cosmology

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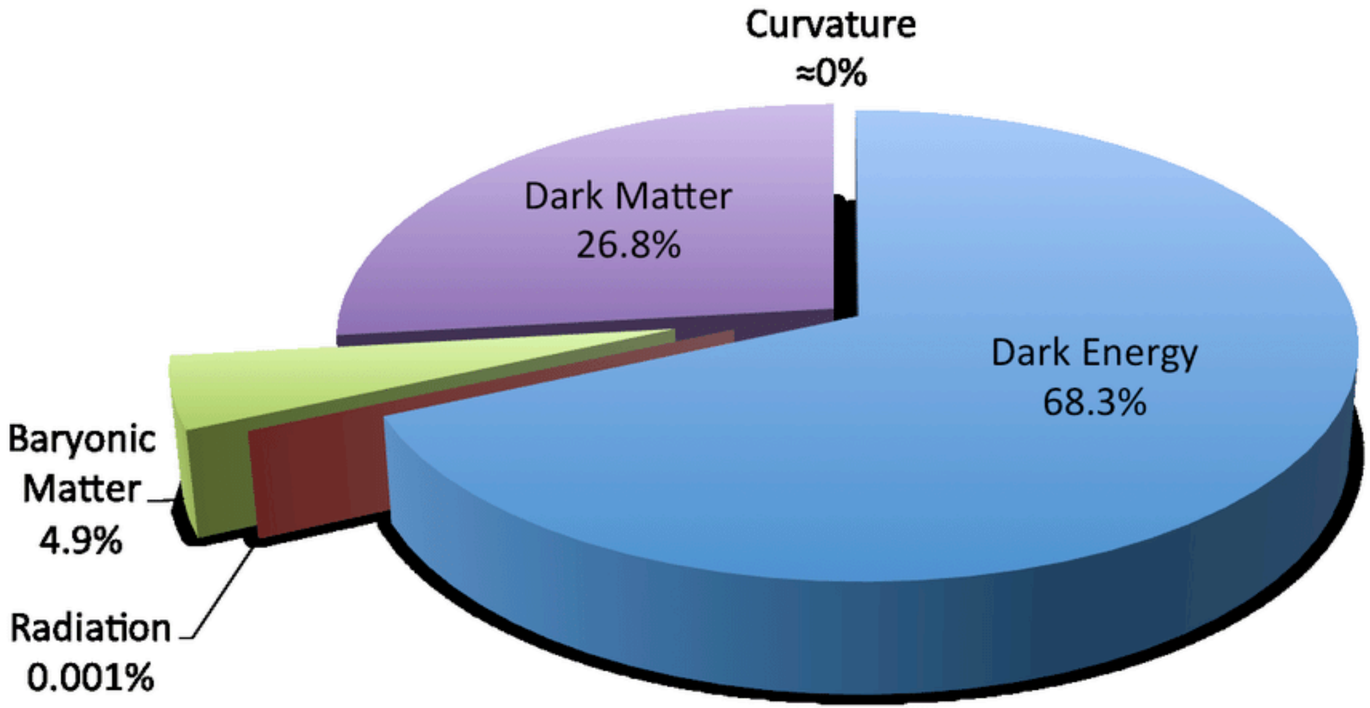
WP3: unknown 95% of the universe



- Nature and properties of dark matter?
- Nature and properties of dark energy? cosmological constant or not?
- Beyond ΛCDM cosmological model?

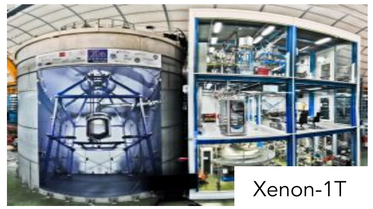
Dark matter searches

Dark matter - complementary approaches

Dark matter

Standard model particles

Direct detection



Xenon-1T

WIMP-DM/nucleus:
Xenon-1T, LUX, etc.

Axion-DM/photons:
HAYSTAC, ADMX

Indirect detection

Fermi

DM annihilation/decay

→ CRs: e+, pbar, dbar (AMS-02)
→ photons: gamma, X, radio (Fermi-LAT, HESS, etc.)
→ neutrinos (IceCube, etc.)

Particle colliders

ATLAS

WP1

BSM, new physics

→ LHC: ATLAS, CMS
→ Future leptonic collider?

Astro., gravitational probes

ESA/Hubble, NASA

Cold/warm/SIDM?

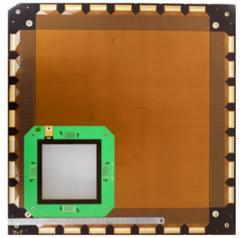
→ abundance of low-mass DM halos.
→ inner DM density, etc.

Dark matter projects in Enigmass

Direct detection

MIMAC - directional direct detection

- 3D nuclear recoil tracks
- Engimass 1 funding: 35 cm bi-chamber low background prototype



- Installation at LSM (Modane)
- First commissioning run in 06/21

NEWS-G experiment

- Focus on low-mass WIMP or KK axion events
- Installed as SNOLAB
- First run early 2021

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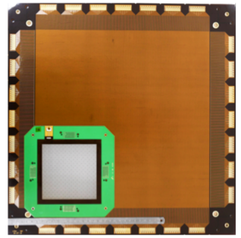

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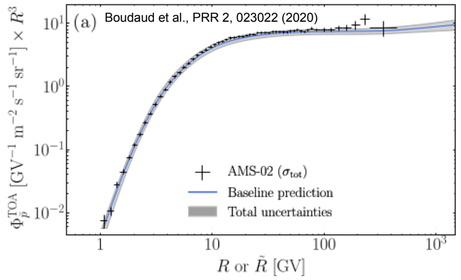
Indirect detection

In cosmic-rays: AMS-02 + pheno.

Find an excess of anti-matter CR, w.r.t to expected astrophysical signal

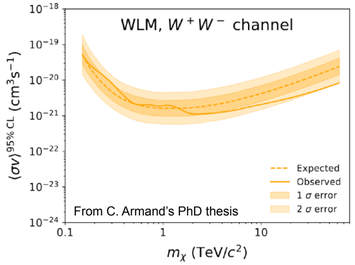


- AMS-02 data analysis of anti-matter CR: e+, pbar (done), dbar
- Derive DM constraints

In gamma-rays (HESS, CTA, Fermi-LAT)

Find an excess of gamma-rays, w.r.t to expected astrophysical signal

- WIMP DM constraints with current data and different targets
- Sensitivity predictions for CTA
- Contraints on Axion-like, PBH



Dark matter projects in Enigmass

Direct detection

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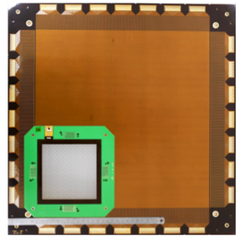

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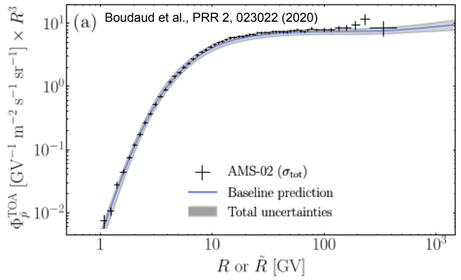

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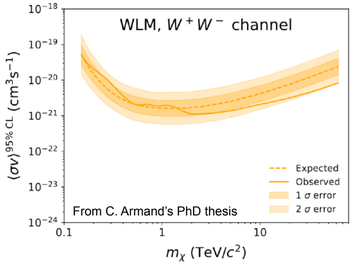


"Astrophysical" searches

What's next if we keep not seeing anything…

What if DM interacts much less than weakly ?

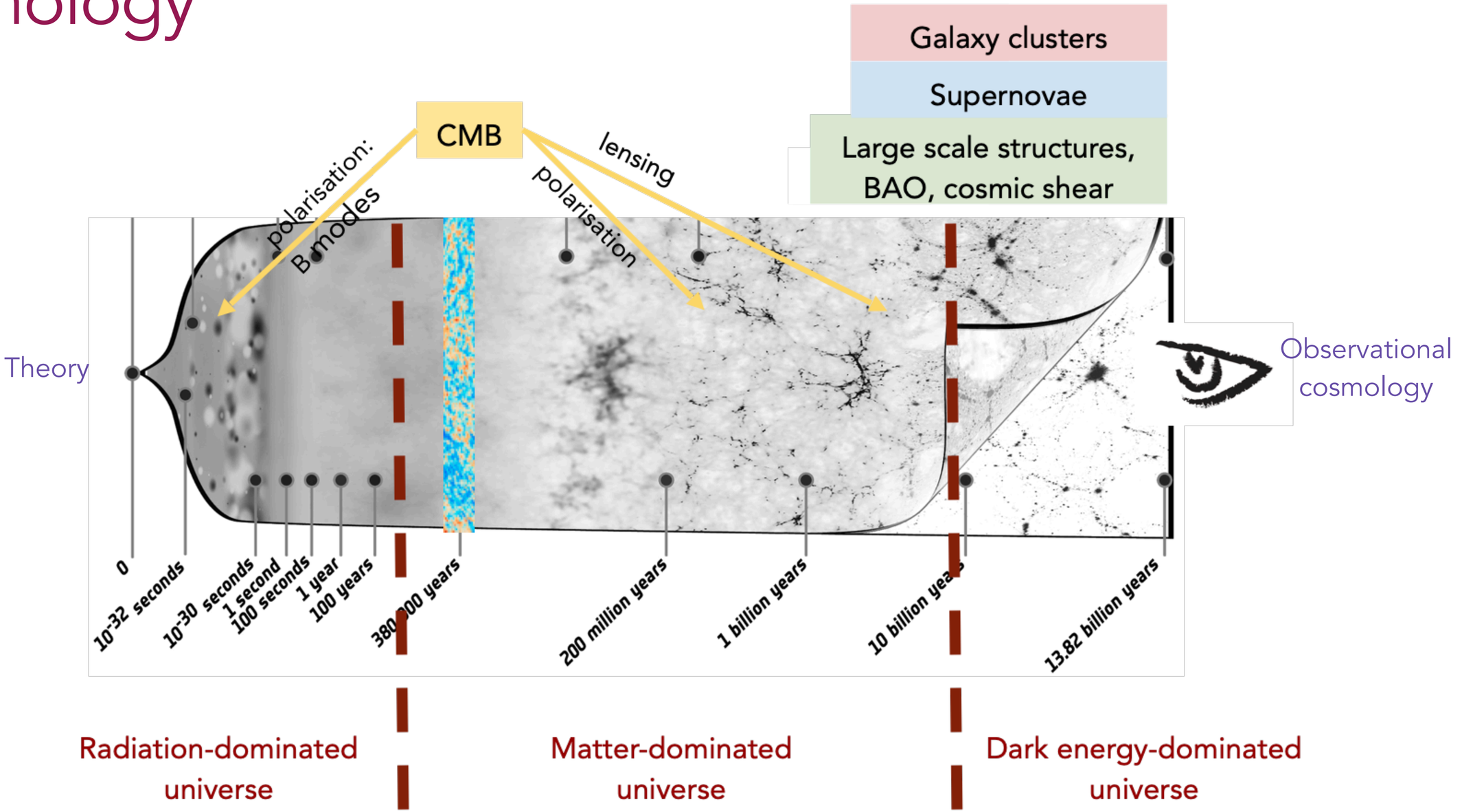
- Study special astrophysical systems as probes, e.g., NS as giant 'DM' detectors

Use gravitational signatures to check if/when the fluid CDM paradigm break up

- Effects of self-interacting DM
- Granularity at small scales from PBH

Cosmology

Cosmology


Galaxy clusters
Supernovae
Large scale structures, BAO, cosmic shear
CMB
polarisation: Bmodes
lensing
polarisation
Theory
Observational cosmology
0
10-32 seconds
10-30 seconds
1 second
100 seconds
1 year
100 years
380 000 years
200 million years
1 billion years
10 billion years
13.82 billion years
Radiation-dominated universe
Matter-dominated universe
Dark energy-dominated universe

Cosmology in Enigmass

Theoretical cosmology

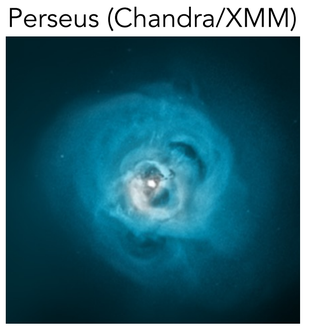
Goal: place observational constraints on theories of gravity beyond general relativity (focusing on cosmology and black holes physics), including quantum gravity.

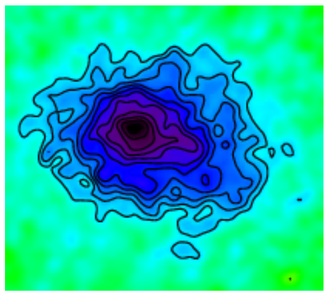
Projects includes

- Constaints from the Rubin observatory, Euclid & SKA on the string theory swampland.
- Quantum cosmology: Developement of more generic formalism for the Loop Quantum Gravtiy model

Observational cosmology, focusing on galaxy clusters

- Main focus of Enigmass observational cosmologists
- Clusters are the largest gravitationally bound structures in the Universe
- Cluster abundance is sensitive to cosmology, including dark energy
- Using cluster for cosmology requires understanding of their multi-wavelength properties (astrophysics)



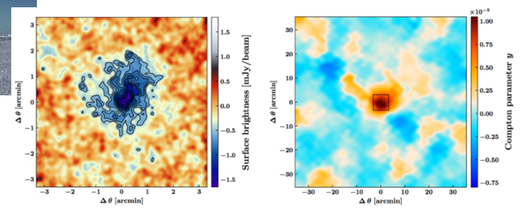


Observational cosmology in Enigmass

mm-wavelength (KIDs)

NIKA2

- Dual-band mm camera installed at IRAM
- Development of the instrument
- LPSZ : a follow-up of Planck and ACT clusters for **cluster cosmology**

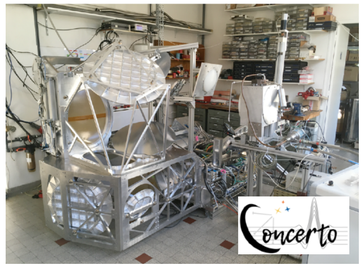


KISS, pathfinder of Concerto

Low resolution spectroscopy observations of **galaxy clusters**

KISS: QUIJOTE telescope in Tenerife

Concerto: APEX telescope in Atacama (03/21)



LiteBird (CMB experiment)

JAXA and ESA satellite experiment for measure CMB polarization anisotropies targeting primordial B-modes. Instrumental contribution so far.

Optical, NIR

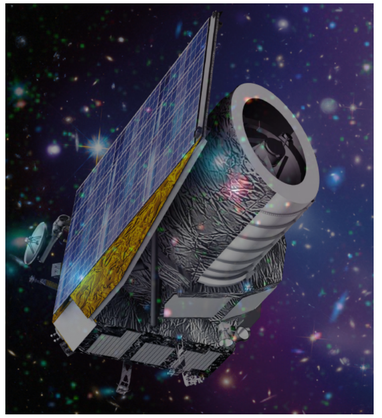
Rubin observatory - LSST

- Ground-based optical instrument
- 10 year survey to exploit late-universe probes for cosmology and dark energy
- Contribution to the camera construction and calibration

Enigmass cosmologists are preparing the **cluster cosmological analyses** from both Rubin and Euclid data. Expected synergies

Euclid

- Space-borne optical/IR instrument
- ~6 year survey to exploit late-universe probes for cosmology and dark energy
- Instrumental developments: electronics, noise characterisation of the NISP



WP3 - Summary

	LAPP	LAPTh	LPSC	Link to WP2
DM direct detection			X	
DM indirect detection (cosmic rays)		X	X	AMS-02
DM indirect detection (gamma)	X	X	X	HESS, CTA
DM from astro. probes		X		
cosmology - Theory			X	
(cluster) cosmology - mm			X	
(cluster) cosmology - optical	X		X	Rubin/LSST (transient sky)

WP3 - Summary

- Many activities and projects in Enigmass to tackle the unknown 95% of the universe
  - Important contributions to major projects of the coming decade
  - Development of new experiments, concepts
  - Theoretical/phenomenology and data analyses

- 2020: Enigmass-funded WP3 postdocs on
  - Astrophysical/gravitational probes of dark matter (A. Joglekar)
  - Cluster cosmology with NIKA2 (E. Artis) and LSST (C. Murray)