Pheno and GW group

Alberto Mariotti

IIHE meeting

15 November 2023

BSM open questions

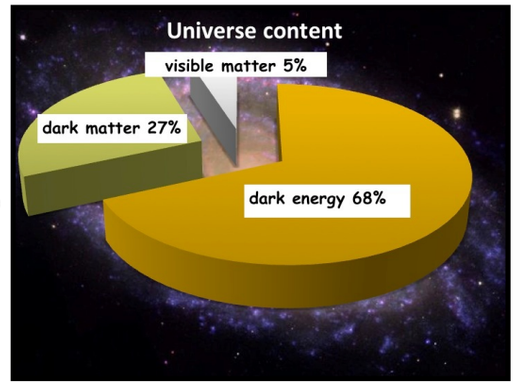
Many fundamental questions still open …

Hierarchy problem ?

Force Unification ?

Inflation ?

Dark matter nature?



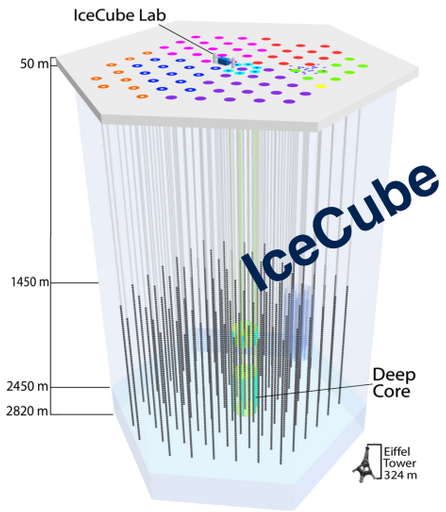
Flavour hierarchies ?

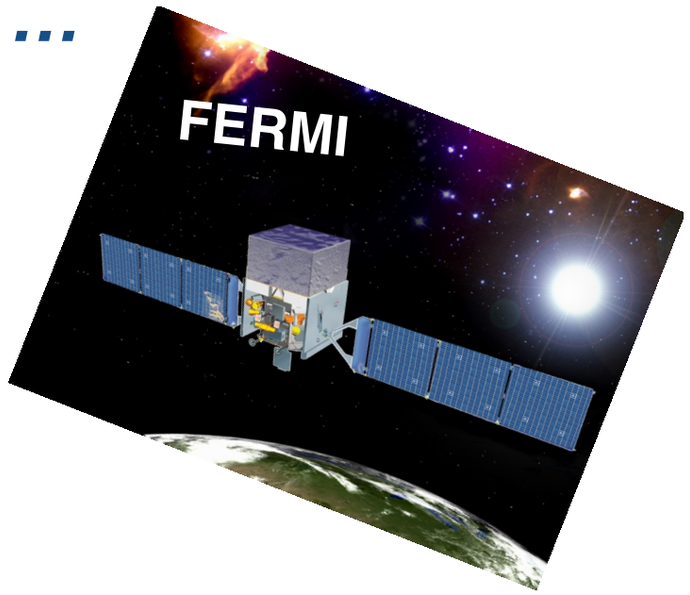
Baryogenesis ?

? What's next in Beyond Standard Model physics ?

Beyond Standard Model Physics

Many experiments can probe it …

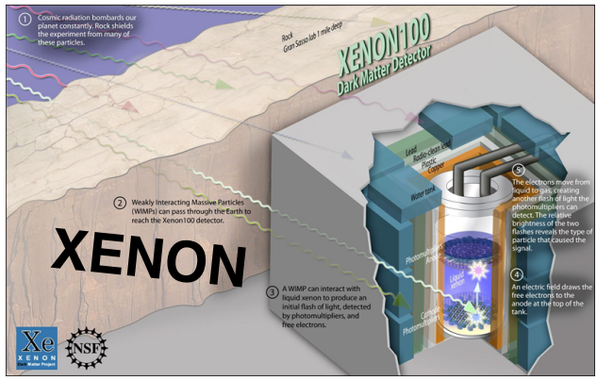




SoLid

JUNO

VIRGO



? What's signal for Beyond Standard Model physics ?

The group on BSM and GW physics

STAFF

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Alex Sevrin

POSTDOC

Miguel Vanvlasselaer

Alba Romero

PHD

Kevin Turbang

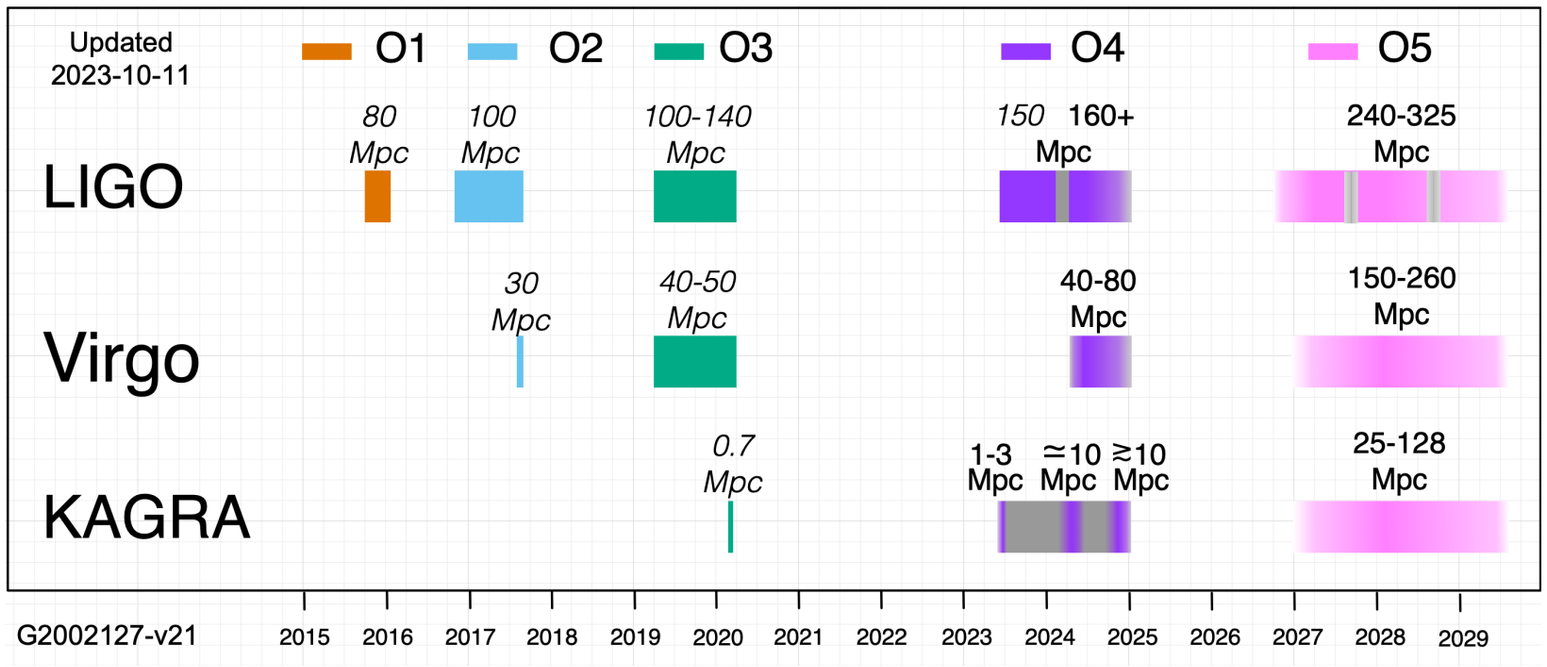
Aaron Rase

Hannah Duval

Xander Nagels

GW experiments

Members of LIGO-Virgo-Kagra collaboration



Virgo members in Belgium

BelGrav

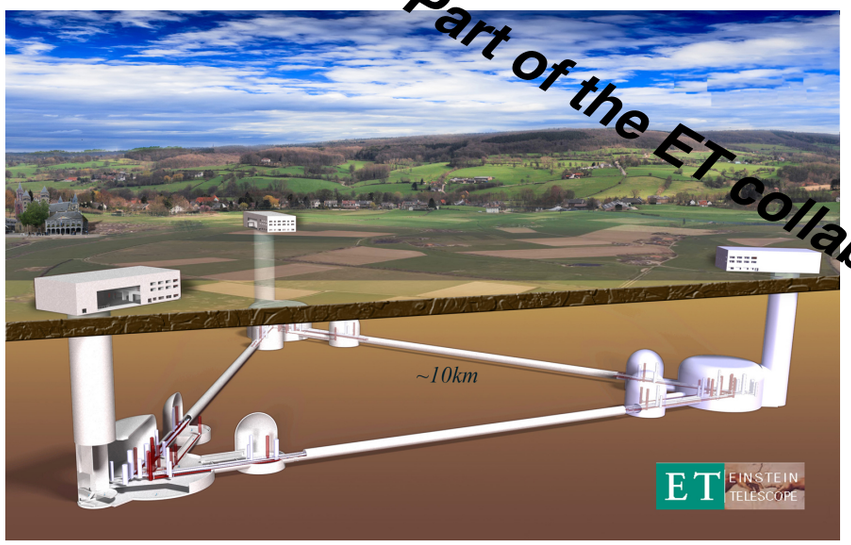
We also work for future 3G detectors

VUB B-PHOT BRUSSELS PHOTONICS

Collaboration with B-Phot

ETpathfinder

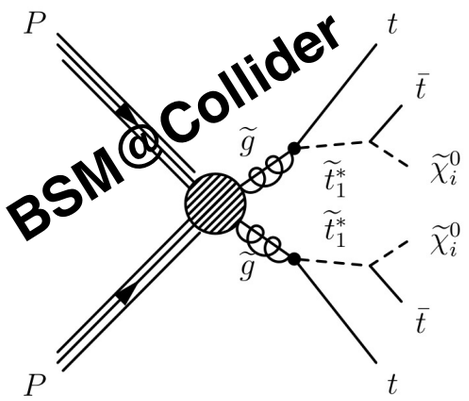
https://www.etpathfinder.eu



Part of the ET collaboration

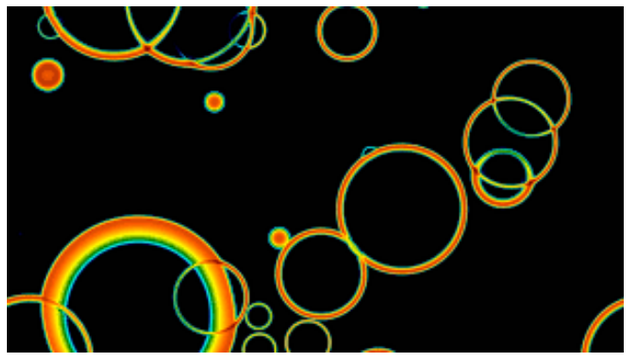
Our research Lines

★BSM at collider

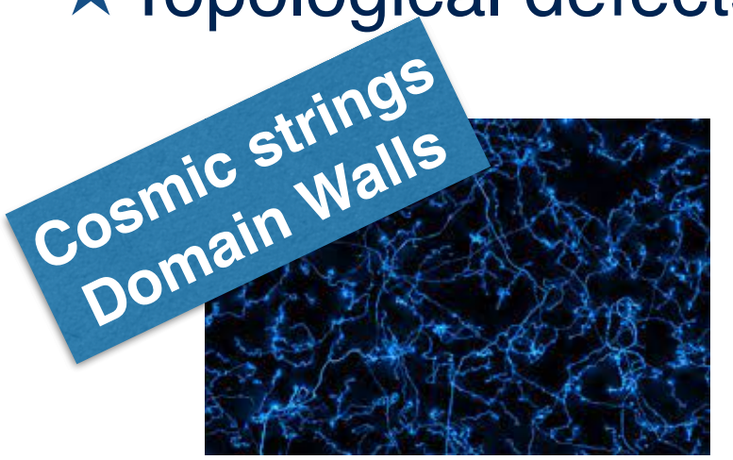


★Dark Matter

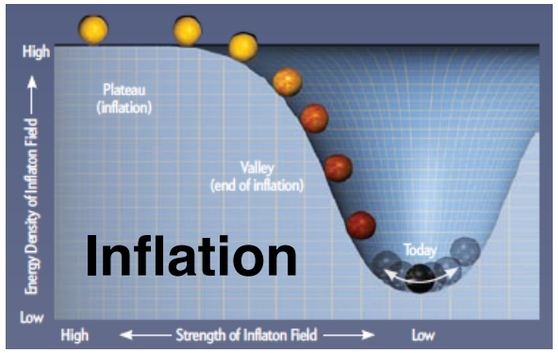
★Phase Transitions



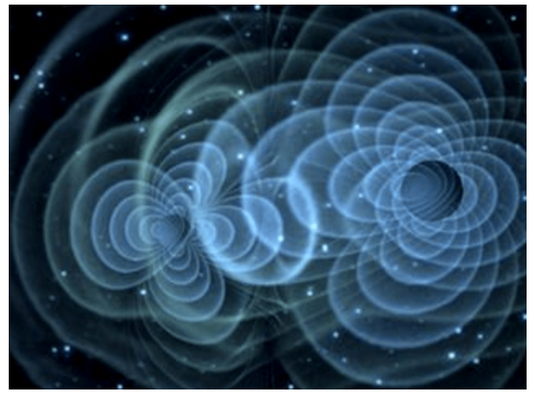
★Topological defects



★Inflation

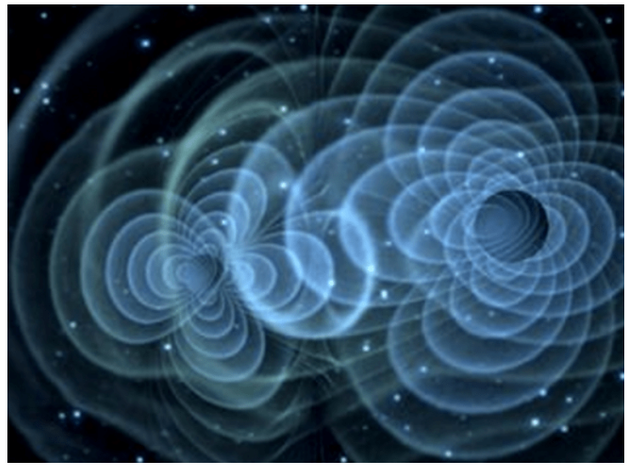


★SGWB and Data analysis for LVK



Stochastic Background of GW

★AstroPhysical SGWB



✳ Superposition of unresolvable sources

BBH ***BNS***

✳ Predictable after LIGO/Virgo observations

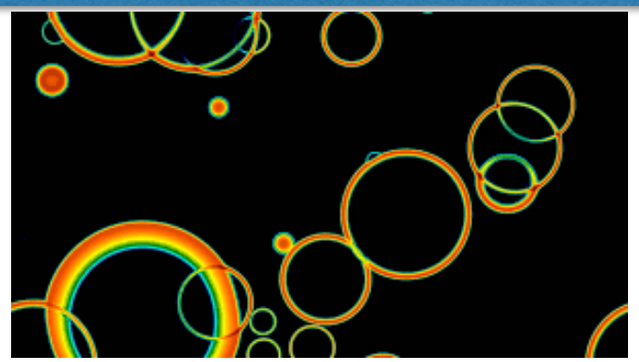
LIGO/Virgo Phys.Rev.D 100 (2019)

! Most likely measured in next few years in LVK!

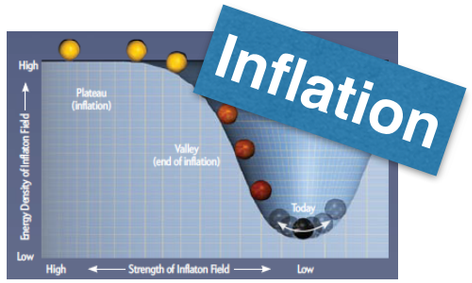
★Cosmological SGWB

✳ Generated by energetic events during cosmological evolution

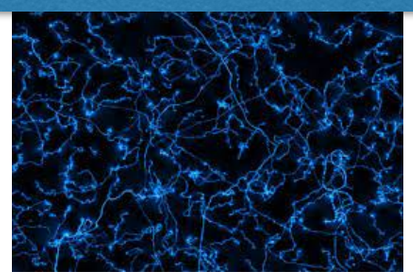
First Order Phase Transitions



arXiv: 1705.01783 D. Weir



Cosmic strings Domain Walls



Explore Universe earlier than CMB!

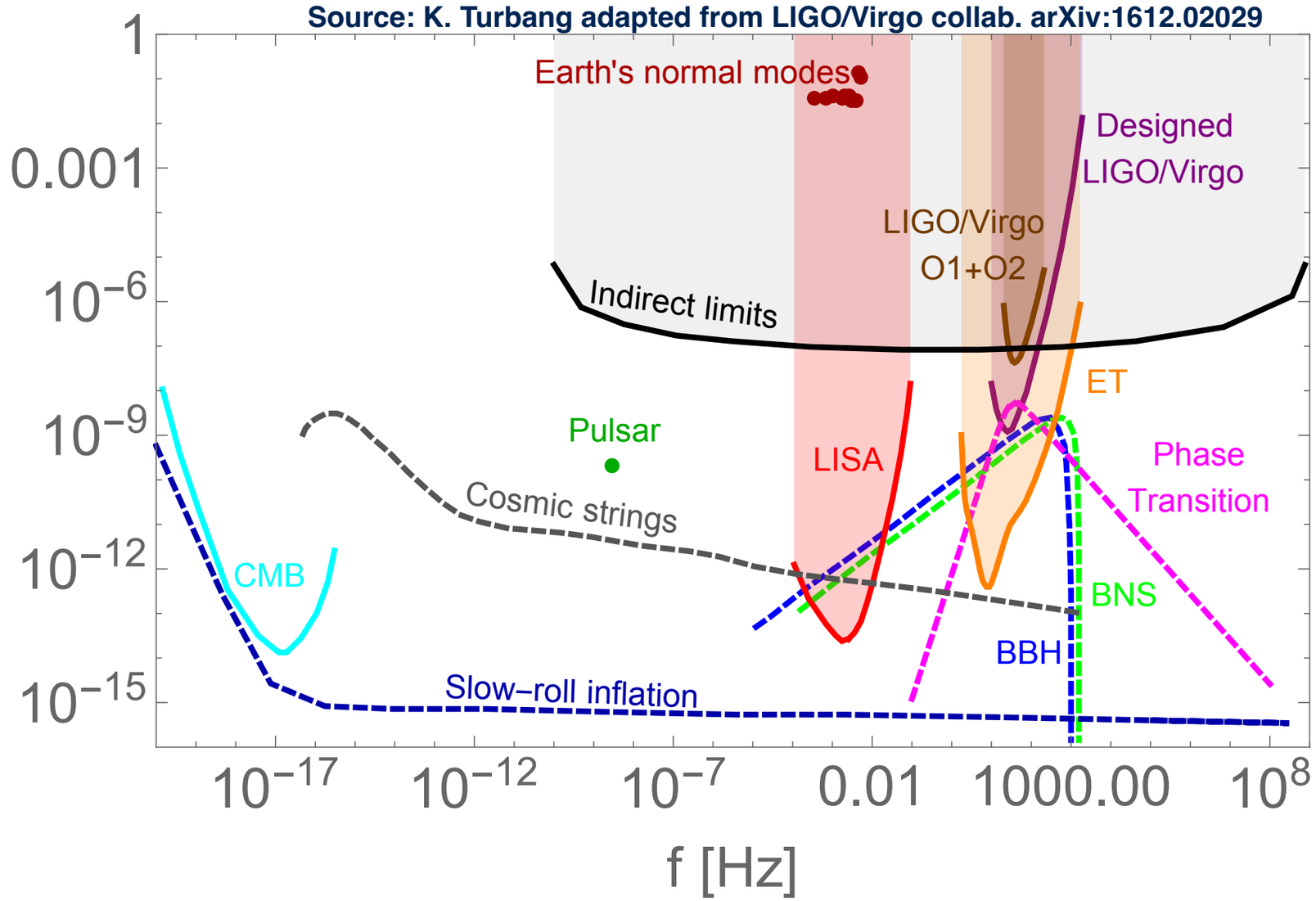
Stochastic Background of GW

WHAT IS IT? *Looks like noise, detected by cross-correlation*

Allen Romano gr-qc/9710117

Analog of CMB but for GW

Source: K. Turbang adapted from LIGO/Virgo collab. arXiv:1612.02029



SGWB energy density over critical one

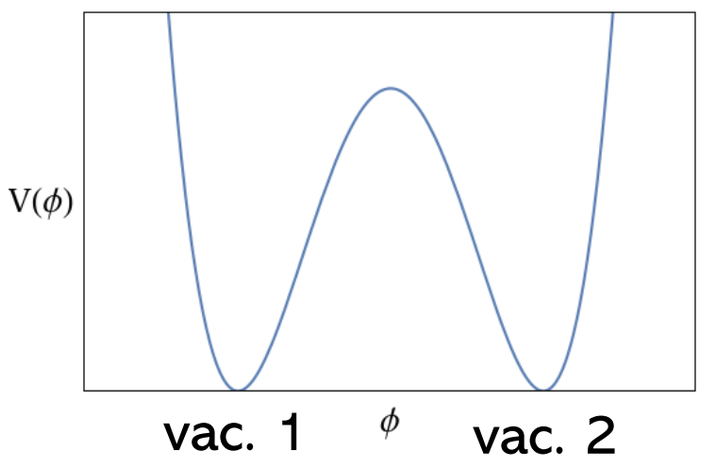
AstroPhysical SGWB ⟷ **Cosmological SGWB**

Experimental probes

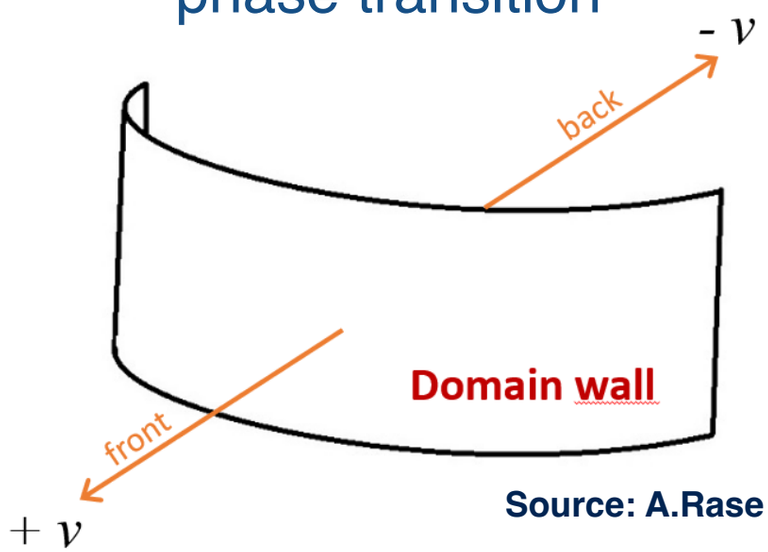
How to disentangle the two?

Domain Wall dynamics

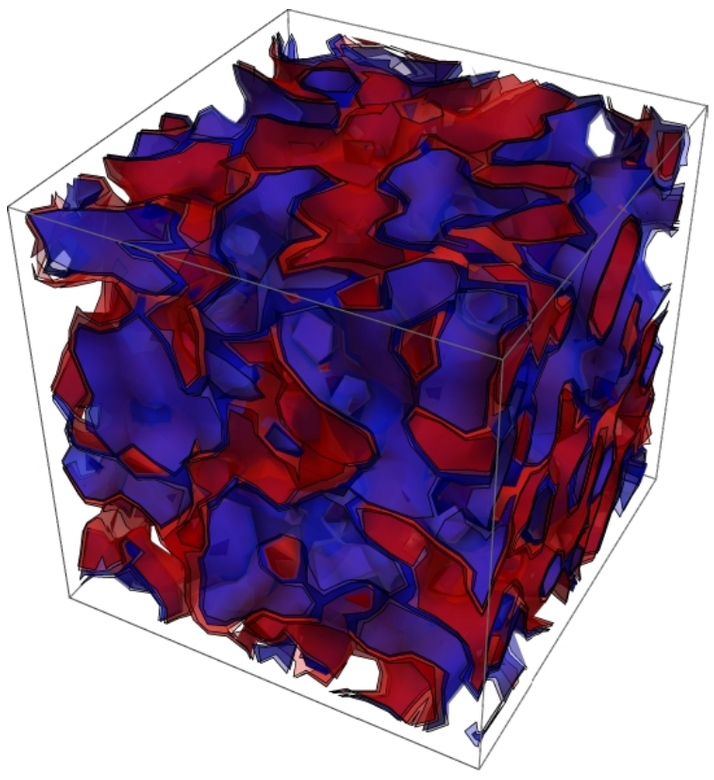
Theory with discrete symmetry spontaneously broken



Domain Walls get formed at phase transition



Source: A.Rase



★Early Universe can be filled by DW network

★Extended object with large energy density (tension)

★Their dynamics/motion induce GW

★Generate a background of GW detectable today

PTA and Domain Walls

★ Recently PTA detected GW background

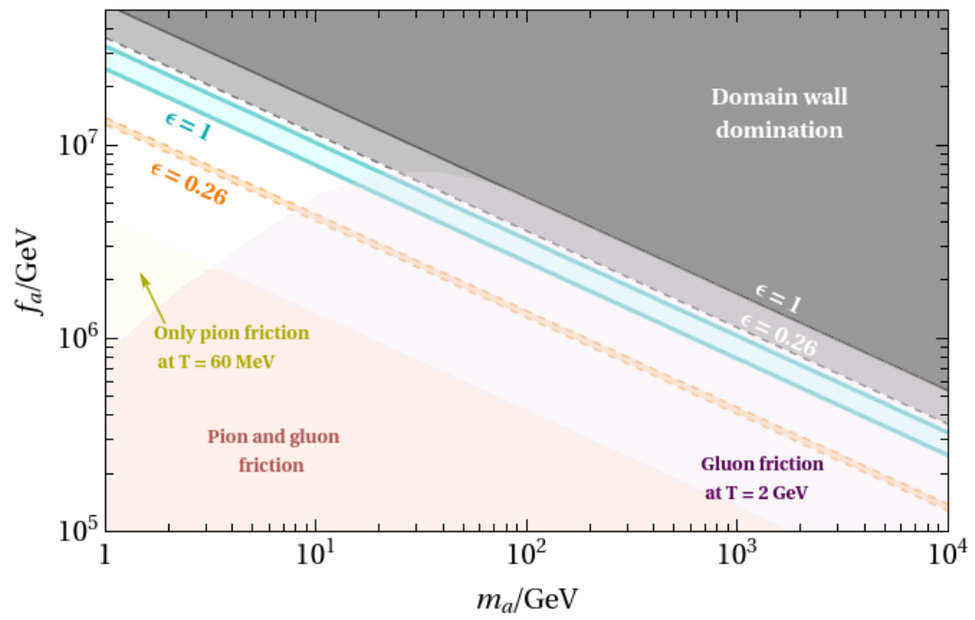
- ✦ Most plausible explanation is astrophysical nature (SMBH)
- ✦ Can it be instead a GWB of cosmological origin?

Domain Wall interpretation of PTA signal

★ Friction from thermal primordial plasma must be included

arXiv:2306.17830
S. Blasi, AM, A. Rase, A. Sevrin

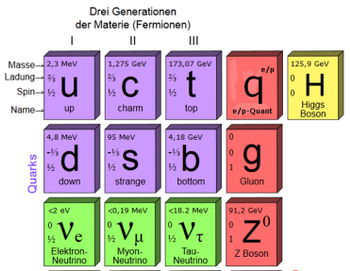
DW in axion model can explain signal → *Friction from gluon and pions in thermal plasma*



First Order Phase Transitions

- ✦Discontinuous Transition between symmetric to non-symmetric phase (order parameter)
- ✦Characterized by bubble formation
- ✦***Bubbles can source GW***

★*In the Standard Model*



✳QCD Phase Transition (T ~ GeV)? In SM No first order

✳EW Phase Transition (T~ 100 GeV)? In SM No first order

(If very light Higgs it could have been strongly first order)
'81 Witten

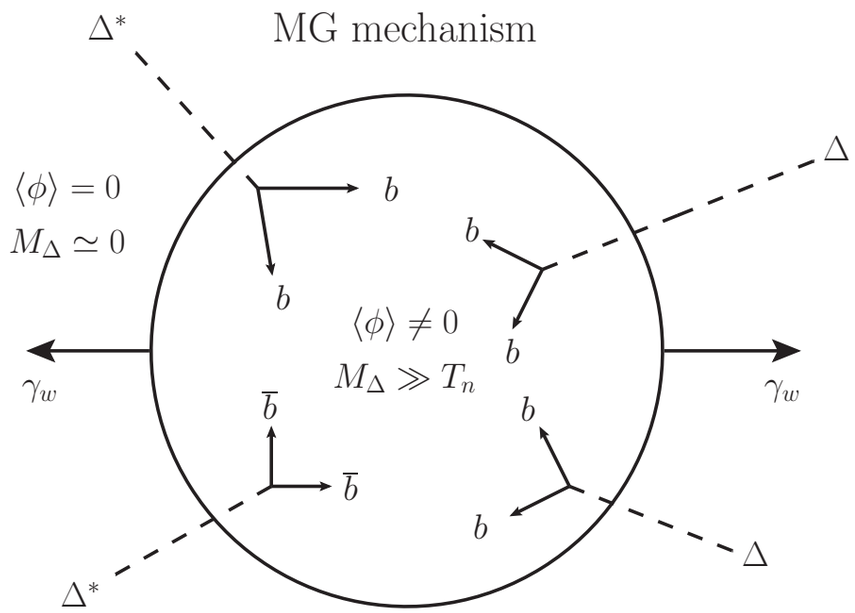
FOPT is signal of BSM physics

★*In Beyond the Standard Model*

- *Modify EW or QCD phase transition*
- *New symmetries which undergo PT*
- *PT in dark sectors*

Matter-Antimatter asymmetry and GW

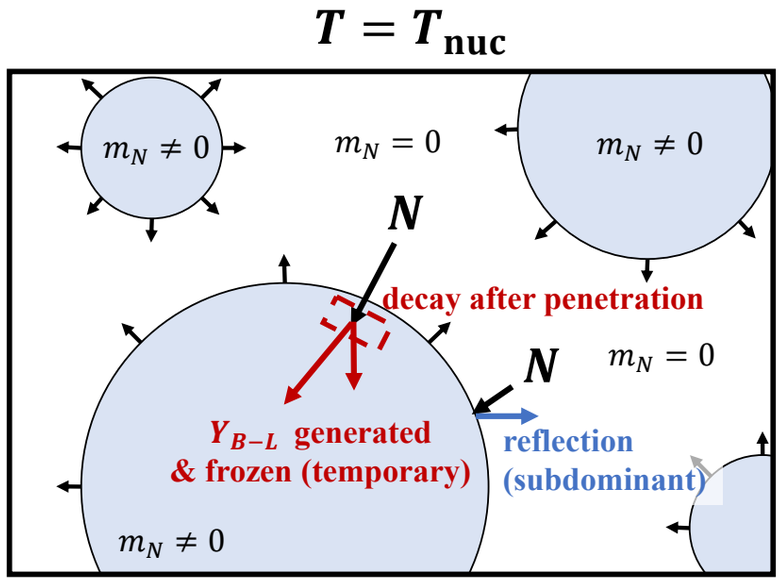
arXiv:2106.15602
I.Baldes, S.Blasi, AM, A.Sevrin, K.Turbang



Sakarov conditions for baryogenesis can be met at bubble of FOPT

- ✳ *Depart from Equilibrium*
- ✳ *CP violation*
- ✳ *B violation*

- ✦ *Strong First Order PT in the Early universe can produce BSM heavy particles*
- ✦ *They can have B violating decay*
- ✦ *FOPT also lead to GW signals*



arXiv:2305.10759
E.Chun, T. Dutka, T.Jung, X.Nagels, M.Vanvlasselaer

Similar mechanism can work with leptogenesis

Detailed study show that this scenario has GW in reach of future experiments

Pheno Life & Network

Common activities with neighbour groups

UCL Université catholique de Louvain

Large Group working in LHC and GW

ULB UNIVERSITÉ LIBRE DE BRUXELLES

Large Pheno Group, expertise in Dark Matter and GW

Typical Pheno Week

★ ***Tuesday at 14:00 Journal Club and Pheno-GW Seminars***

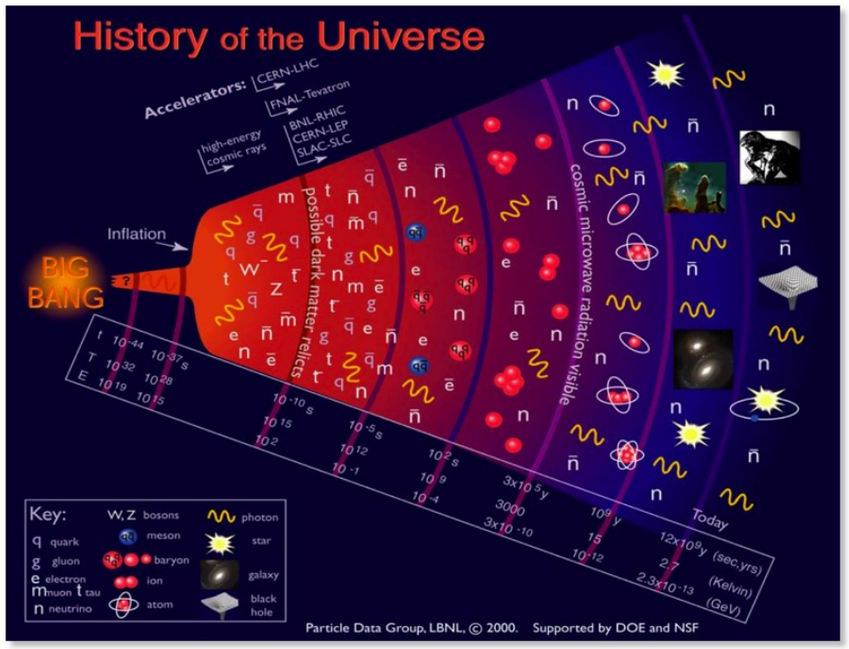
★ ***Wednesday: BelGrav meeting***

★ ***Thursday: HEP@VUB meeting***

★ ***Friday: IIHE seminar and ULB-Pheno seminar***

Conclusions

Many years of interesting Physics are in front of us!



Shedding light into Early History of our Universe