LISA

Laser Interferometer Space Antenna

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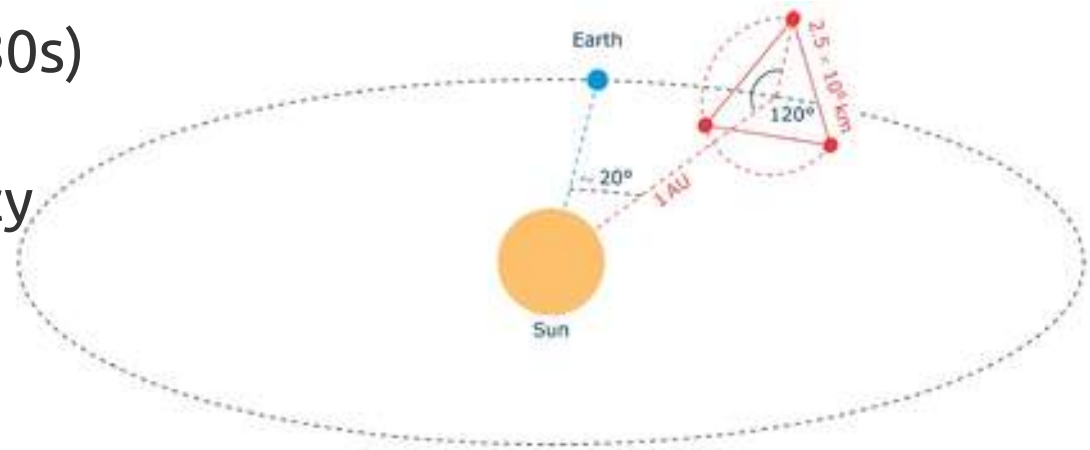
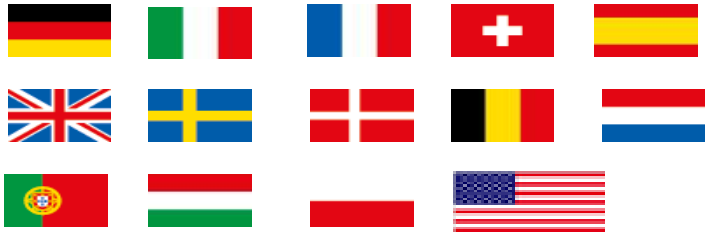
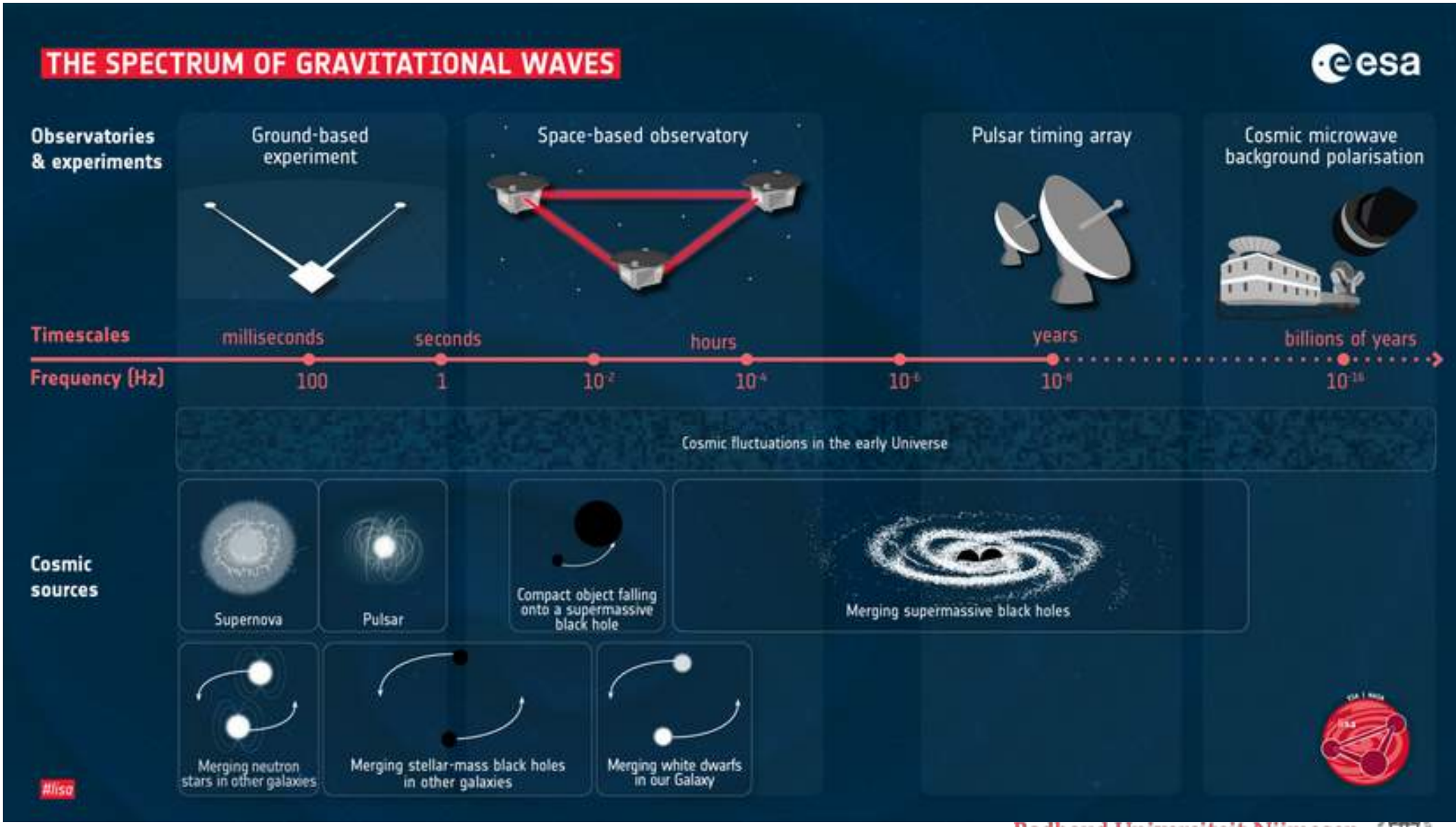
The LISA mission

- Long history (first concepts 1980s)
- *Adopted* European Space Agency (ESA) mission to detect Gravitational Waves in space
- Three satellites in triangular formation, trailing Earth
- ESA lead, member state contributions, strong link with NASA
- Budget: ~3B€ (ESA: 1.75B€, NASA: ~800M€, Member states: ~500M€)
- Sensitive in mHz regime
- Launch planned in 2035



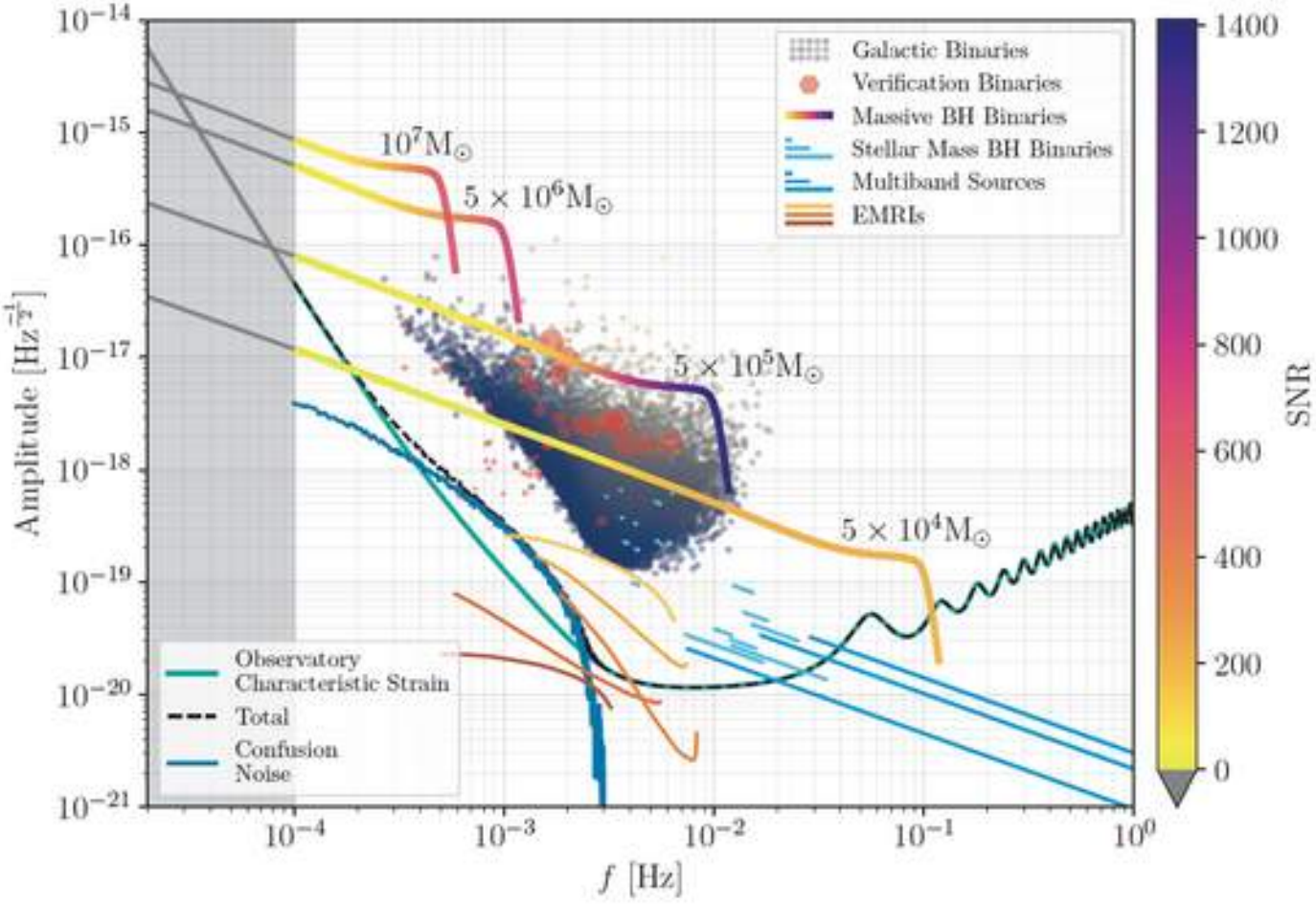


How LISA fits in the GW spectrum



Space GW: sources

- Super Massive black hole binaries (10^5 – 10^7 M_o)
- Compact binaries (in the Galaxy)
- Stellar BH binaries
- Extreme Mass-ratio Inspirals
- Early Universe: GW background, cosmic strings,
- Astrophysical backgrounds
- The unknown

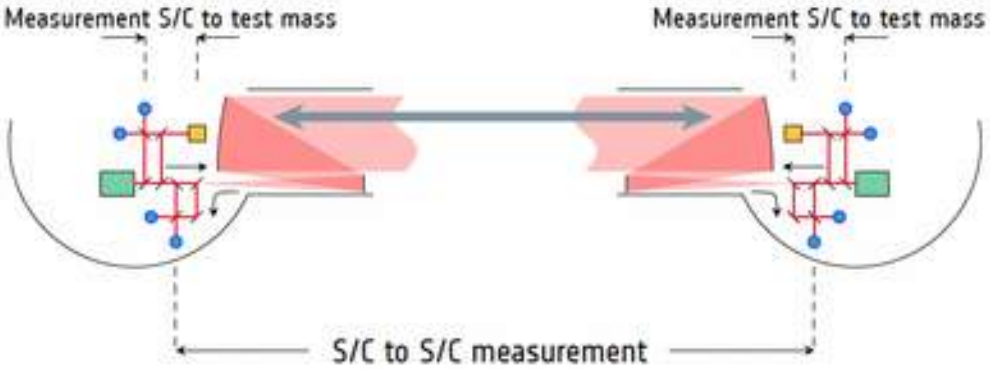


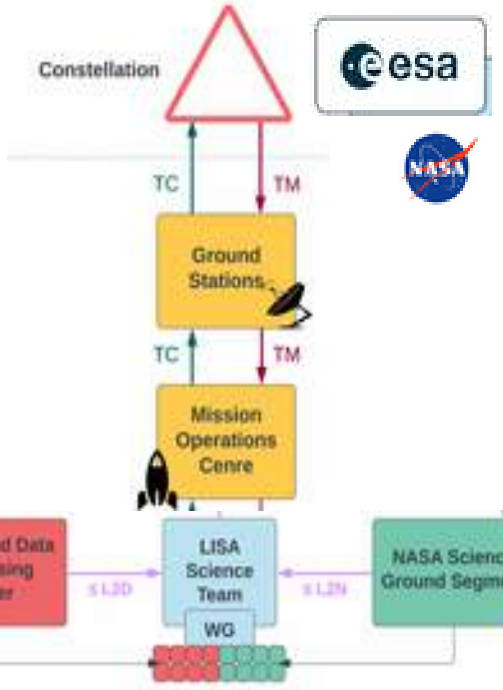
Space GW: revolutionary science

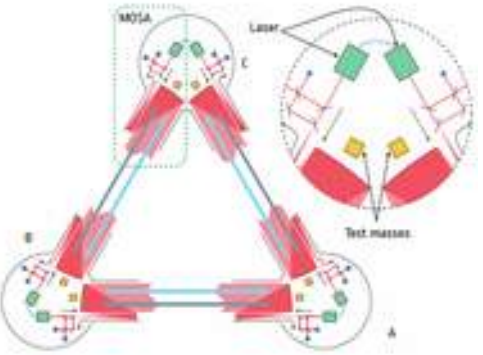
- Formation and evolution of compact binaries & Milky Way structure
  - Measure thousands of binaries, some with high accuracy
  - Chart population and Milky Way structure
  - Some also EM sources
- Astrophysics of stellar-mass black holes
  - Measure eccentricities
  - Multi-band sources
- Trace origins, growth and merger histories of massive black holes
  - Accurate masses and spins throughout Universe
  - Synergy with EM observations
- Cosmology
  - Standard sirens with MBH and EMRIs
  - Early Universe backgrounds, if they exist
- High-precision fundamental physics and testing GR
  - prove horizon exists; test no-hair theorem,
  - cosmic censorship; search for scalar fields etc
- The unknown

Mission concept

- 2.5 million km arms
- Payload supplied by member states
- Laser, telescope++ provided by NASA
- Critical technology tested by LISA Pathfinder
- Free floating test masses Drag-free control, heterodyne interferometry
- Time delay interferometry
- European (DDPC) and US (NSGS) large data processing efforts







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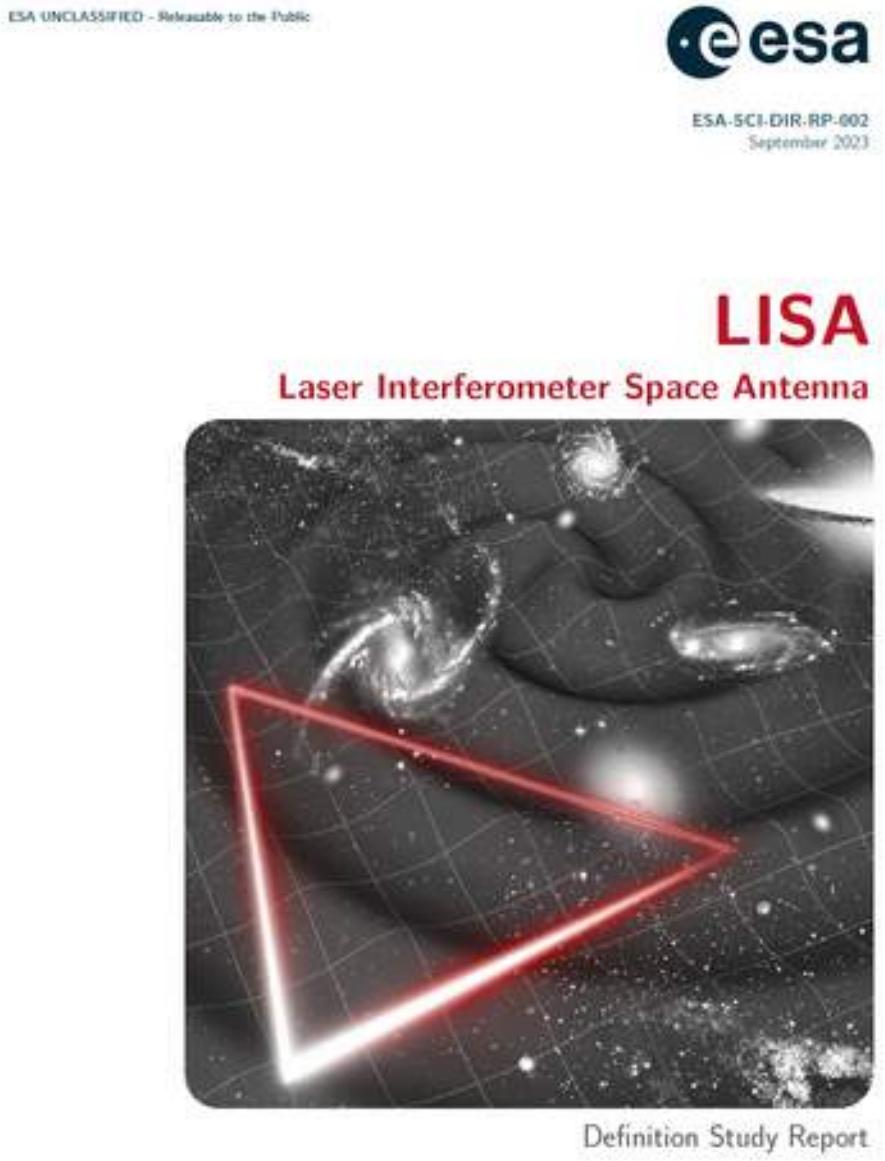
Overview, more information

- mHz GW observatory
- Joint ESA-NASA
- Launch 2035
- Broad science
- Precision technology
- Complex data processing
- More information in “Red book”
- And in the next talks...

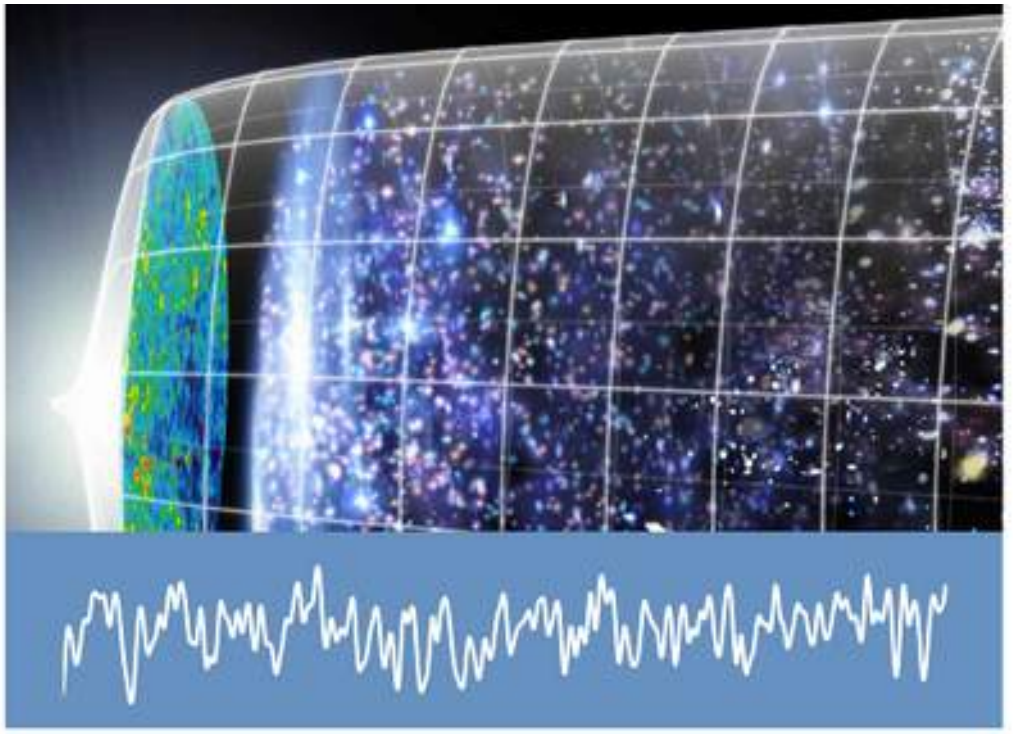


https://arxiv.org/abs/2402.07571

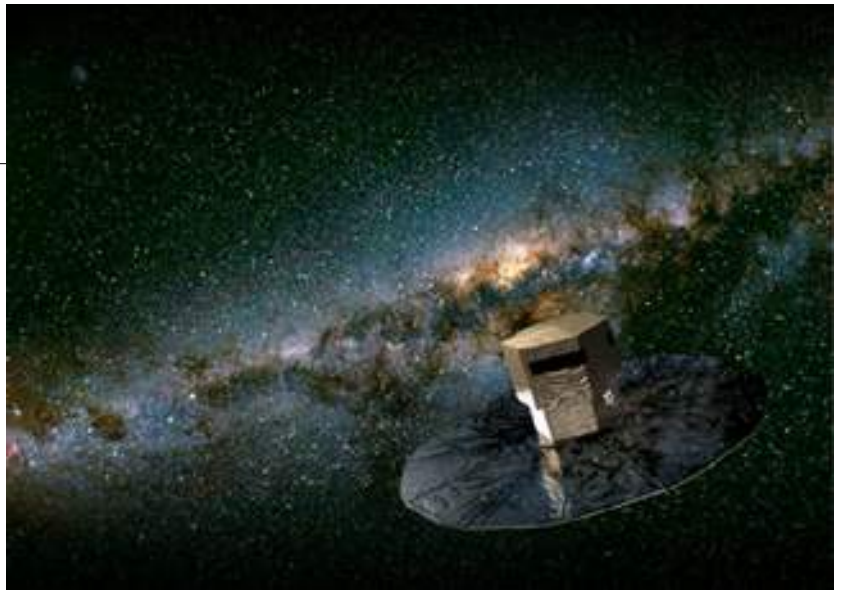
Backup

Dutch contributions

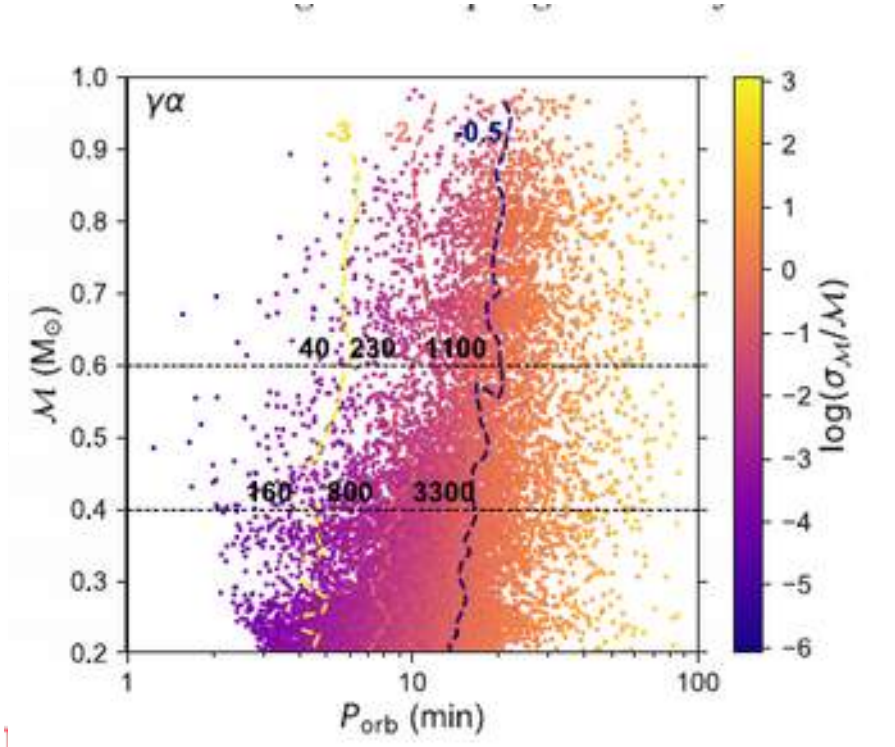
- Science
  - Compact binaries
    (RU, UL, SRON, UvA)
  - Fundamental physics
    (Nikhef, UvA, UU, UM, RU)
  - Early Universe
    (Nikhef, RUG, UU, UL)
  - Structure formation
    (UL, RUG)



Compact binaries

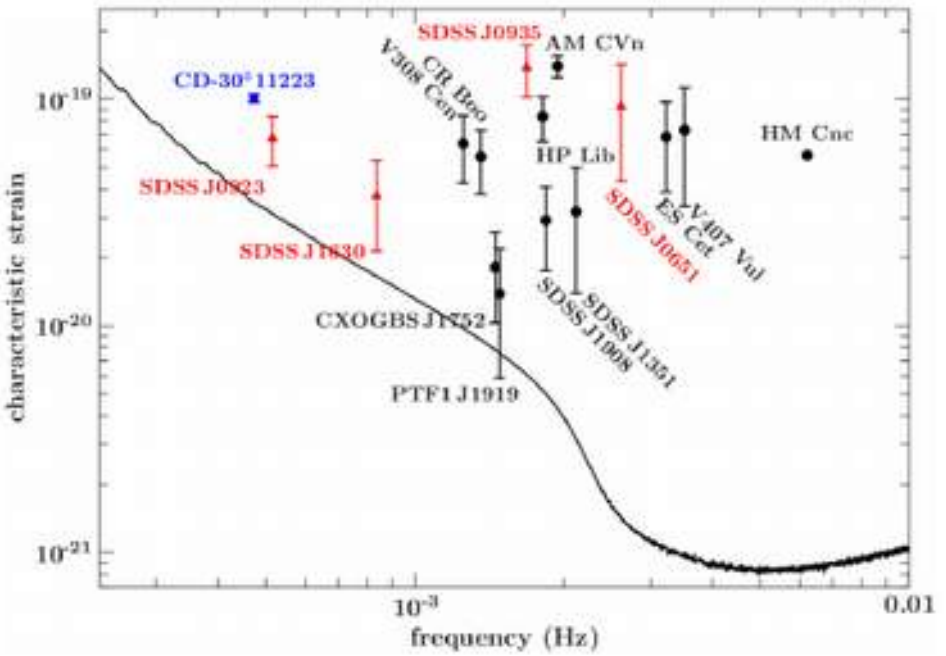


- Many detectable also with Gaia and LSST (Korol et al 2017)
- Ultimate test for existence of massive WD mergerger (Rebassa-Mansergas et al. 2019)
- Imortance of triples (Robson et al. 2018 PRD 98 064012, Antonini et al. 2017 ApJ 841, 77 BBH mergeres from triples)



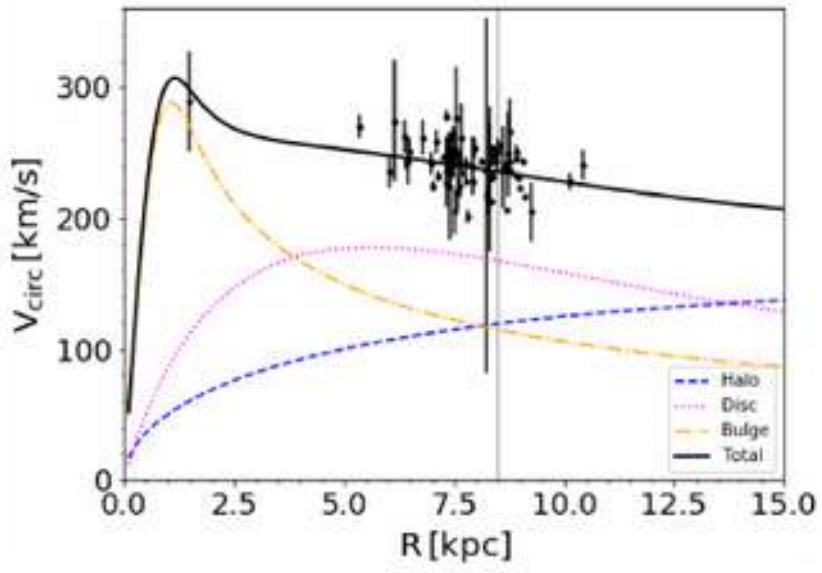
Compact binaries

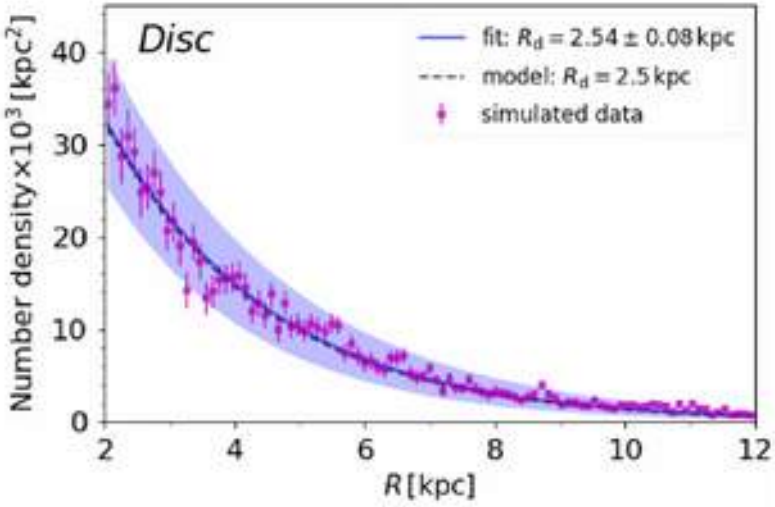
- Verification sources with Gaia distances (Kupfer et al. 2018, MN, 480, 302)
- Also Ramsay et al 2018 (A&A, 620,141)

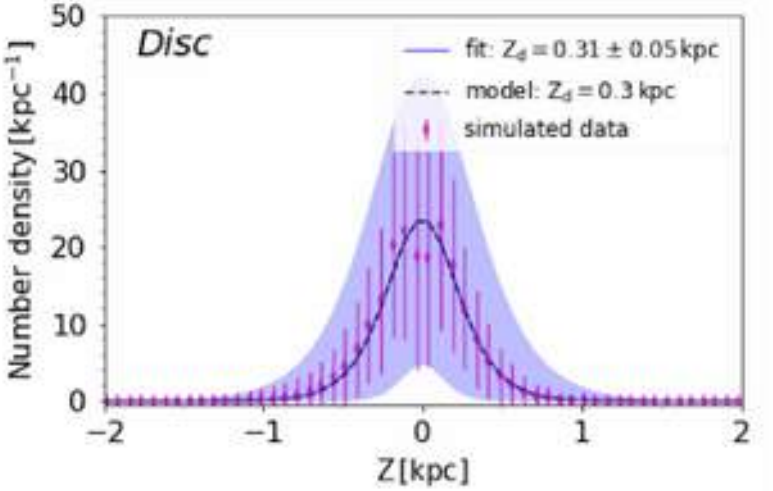


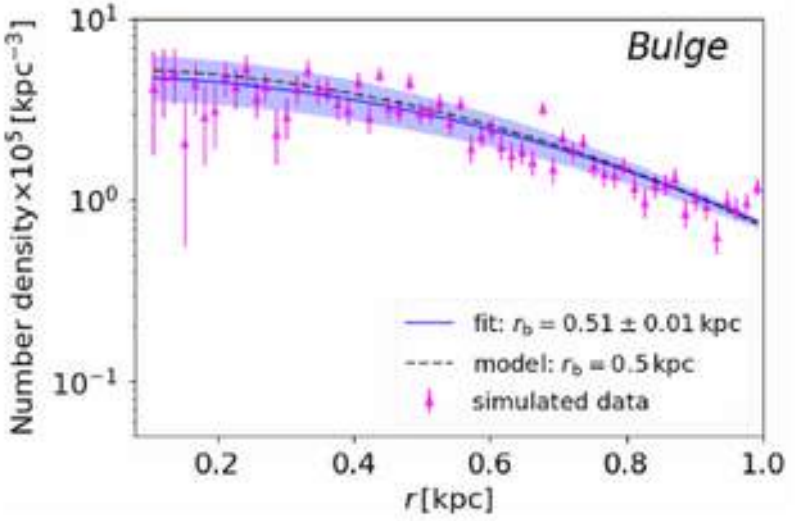
The Milky Way

- Measure structure Milky Way (Korol et al. 2019)
- Several double WD detecatable in M31 (Korol et al. 2018)
- Signals from MW satellites (Korol et al. 2021, MN,502, 55, Roebber et al. 2020, ApJ, 894, 15)



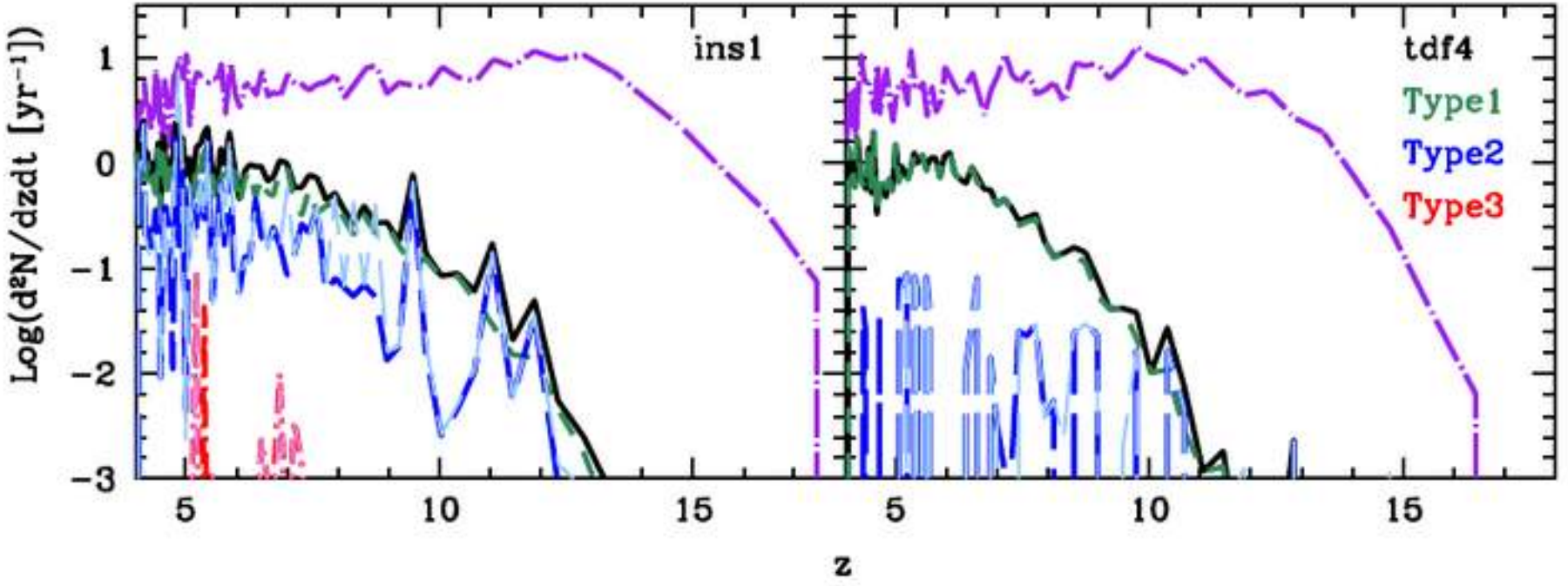






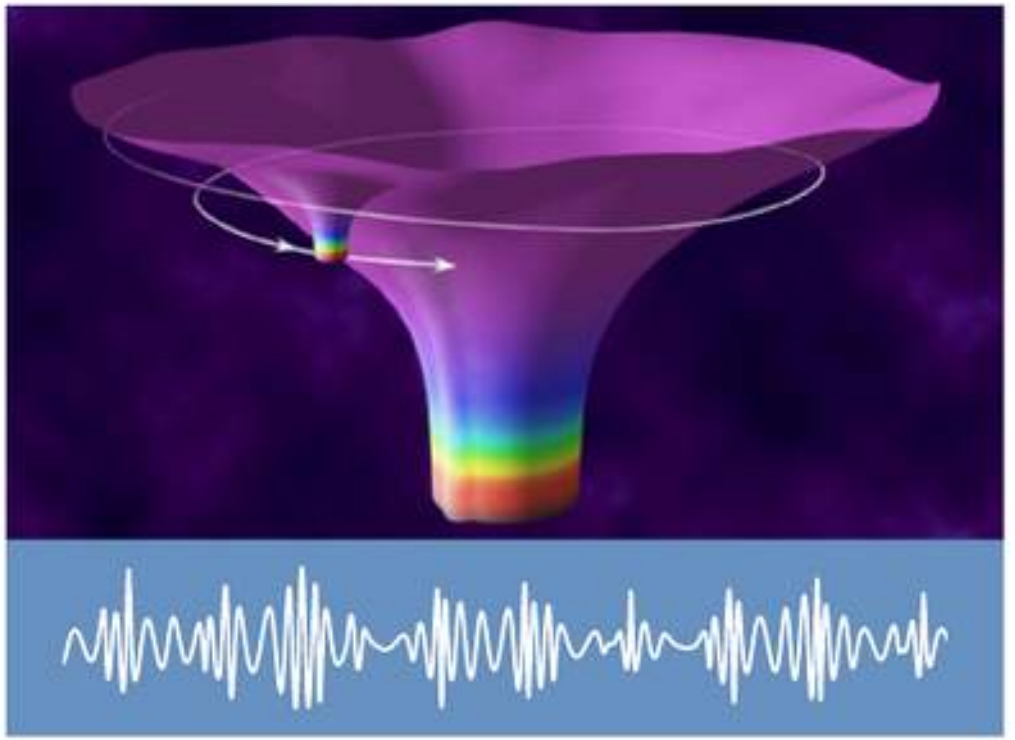
Structure formation/seeds

- Dayal et al. 2019 (MN, 486, 2336)
- Rossi (JphCS, 840, 2027), Toscani et al. 2019, IJMPD, 2844015)
- Also Duncan et al. 2019, ApJ, 876, 110; Salcido et al. 2016 (MN 463, 870)
- Tidal disruptions (Pfister et al. 2021, 2103:05883; Toscani et al. 2020, MN, 498, 507)



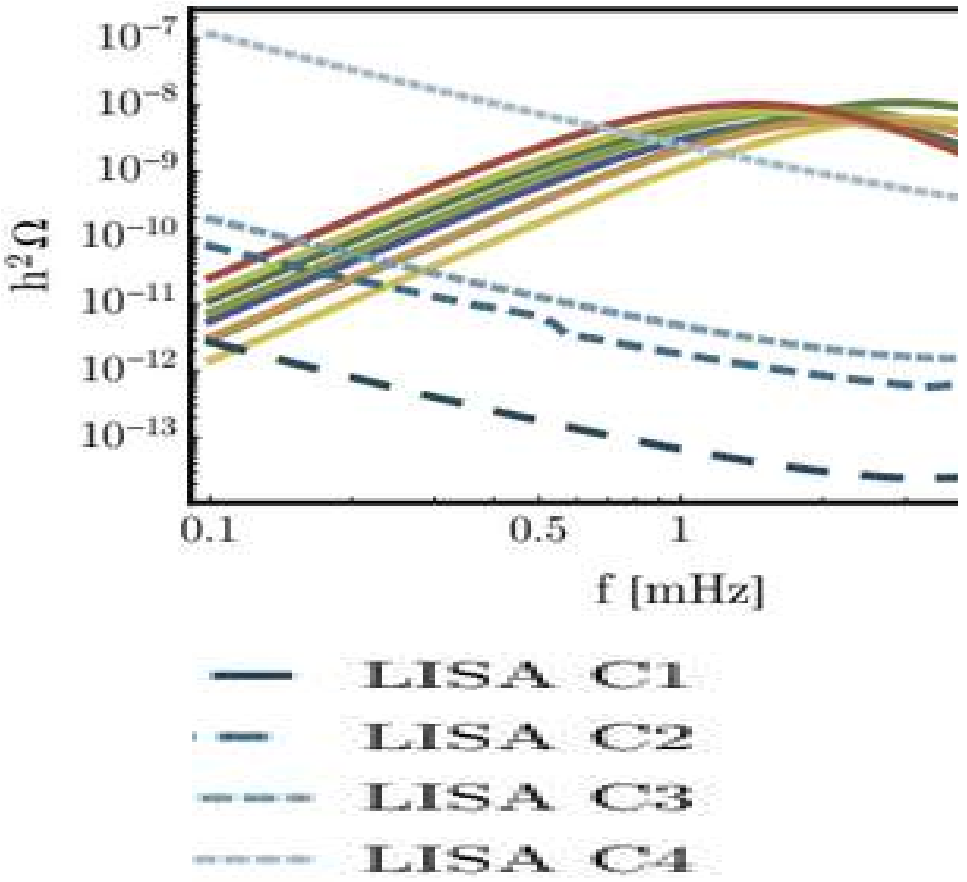
Fundamental physics

- Memory effect, (Nichols 2018 PRD 98f4032)
- Tidal resonances in EMRIs, (Bonga et al. 2019, PRL, 123, 1103)
- Test GR (e.g. Kasta et al. 2018, PRD, 98, 124033)
- Dark matter (Edwards et al, 2020, PRL, 124, 161101)



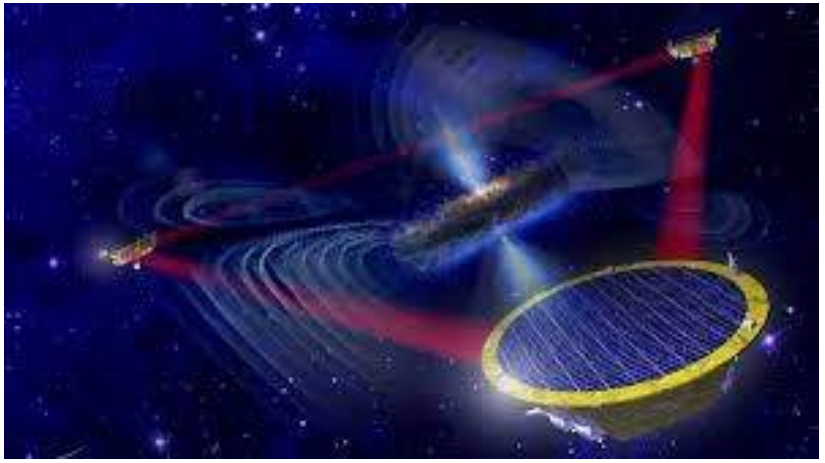
Early Universe/cosmology

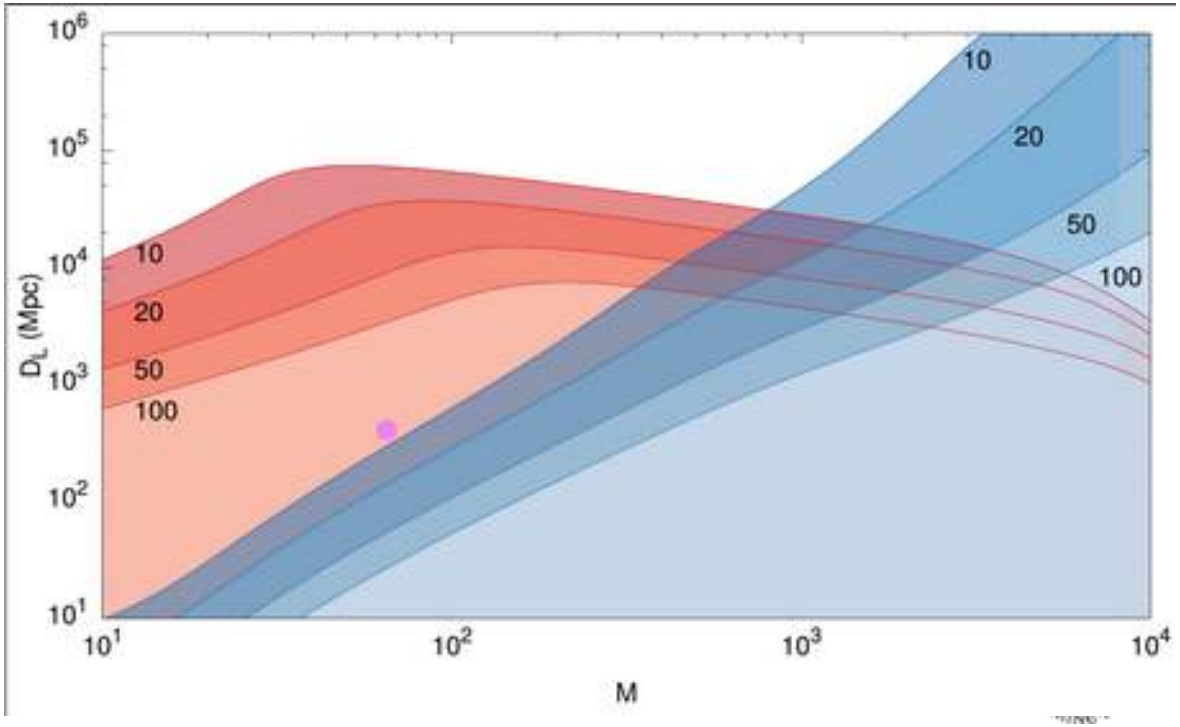
- Phase transition (Prokopec et al. 2019, JCAP, 02, 009)
- Precision cosmology (Mukherjee et al. 2021, PRD, 103, 043520)



Conclusions

- LISA is a great mission for Astronomers and Physicists
- NL (=you!) well posisitoned to be part of the LISA consortium (ask me or Elena Rossi)
- Currently phase A
- Launch far away, descisions and work now!
- Complemtarity LISA and ET





EM follow-up

- BlackGEM
  - Array newly designed telescopes (PI Groot)
  - Installation in Chile onging
  - Dedicated to follow-up GW sources to detect in optical
- Other facilities
  - Coordination via ENGRAVE (Jonker, Levan, Groot)
  - Large programmes on La Palma, ESO (Chile), Hubble Space Telescope etc.

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