Outline

- The Hubble tension
- Cosmology with GWs
- Description of the Galaxy catalogue method
- My work adapted for LISA

The Hubble Tension in Numbers

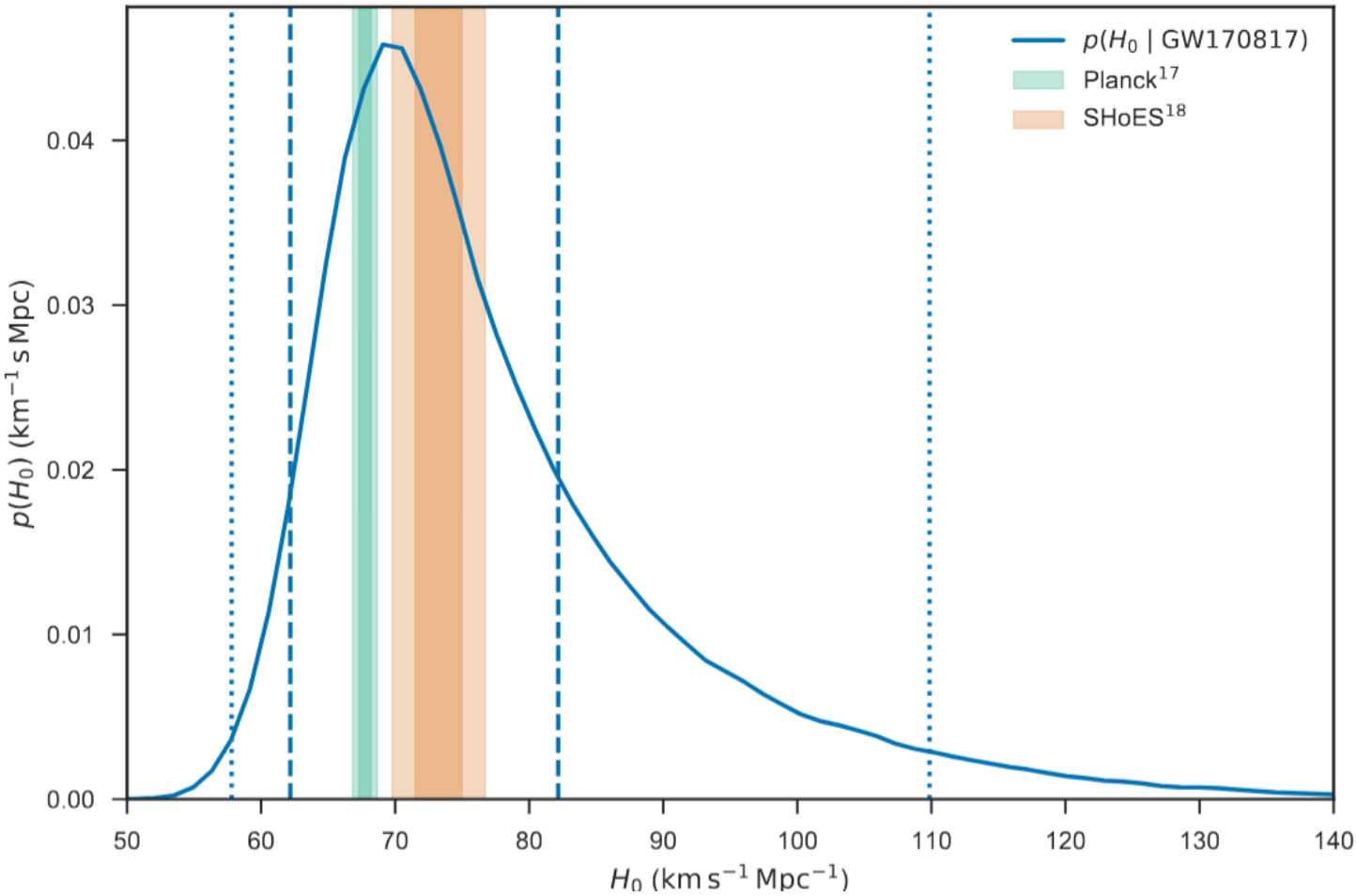


Figure: Posterior distribution of the Hubble constant H_0 from GW170817 (blue). Planck (green) and SHoES (orange) constraints with $1\sigma/2\sigma$ intervals are also shown. The MAP value and 68.3% credible interval are $H_0 = 70.0^{+12.0}_{-8.0}$ km s^{-1} Mpc^{-1}. Dashed and dotted lines show the 68.3% and 95.4% intervals.

Estimating the Hubble Constant H_0

$$D_L(z, H_0) = (1+z) \cdot c \int_0^z \frac{dz'}{H(z')}$$

- D_L measured directly from the gravitational wave signal
- z is the real challenge

Standard Sirens in Gravitational-Wave Cosmology

Gravitational-wave (GW) events can serve as **standard sirens** to measure cosmological parameters, such as the Hubble constant H_0.

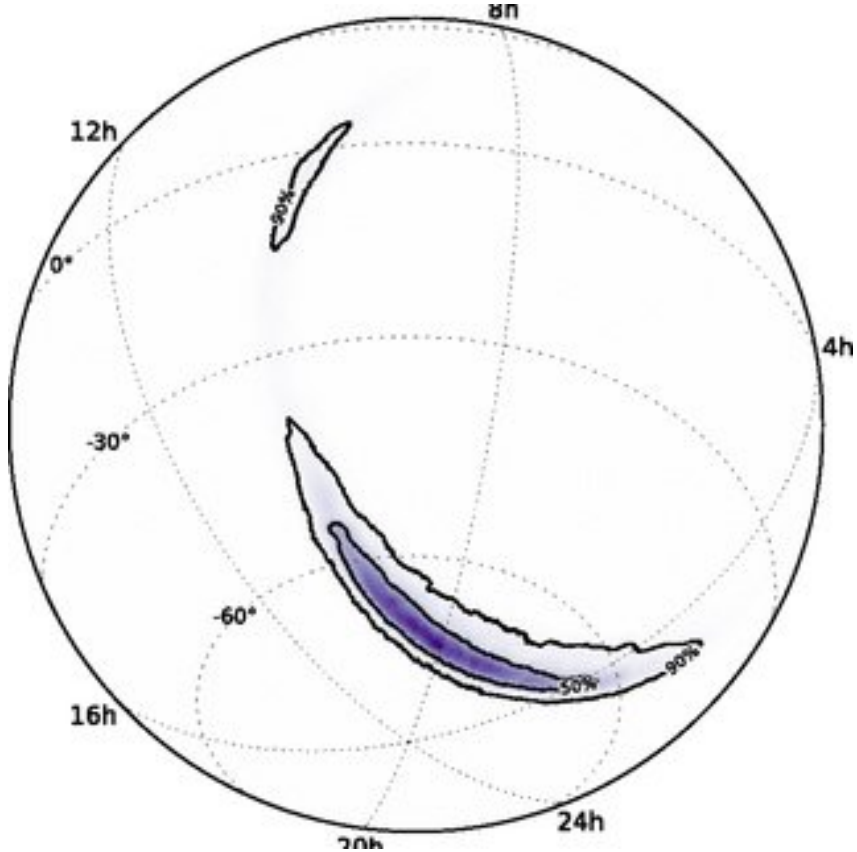
Bright Sirens

- EM counterpart $\rightarrow$ direct redshift
- Example: GW170817 (BNS)
- Precise but very rare (only one known)

Dark Sirens

- No EM counterpart
- Redshift z unknown
- Use galaxy catalogues to infer z or other method
- More common, less precise

Visualizing the Galaxy Catalogue Method



→ Use galaxy catalogues containing positions and redshifts of nearby galaxies.

→ Statistically match the 3D GW localization volume with potential host galaxies.

→ Infer the redshift z to constrain the Hubble constant H_0.

Adapting the Galaxy Catalogue Method for LISA

- I use a well-established galaxy catalogue method, proven effective for dark sirens.
- I adapt this method to simulated galaxy catalogues tailored for LISA sources.
- This ensures to be ready to analyze LISA data with a reliable, tested method.

Goal: have a ready-to-use, reliable method for constraining cosmology with LISA standard sirens.

Choice of Galaxy Catalogues

The catalogue i used:

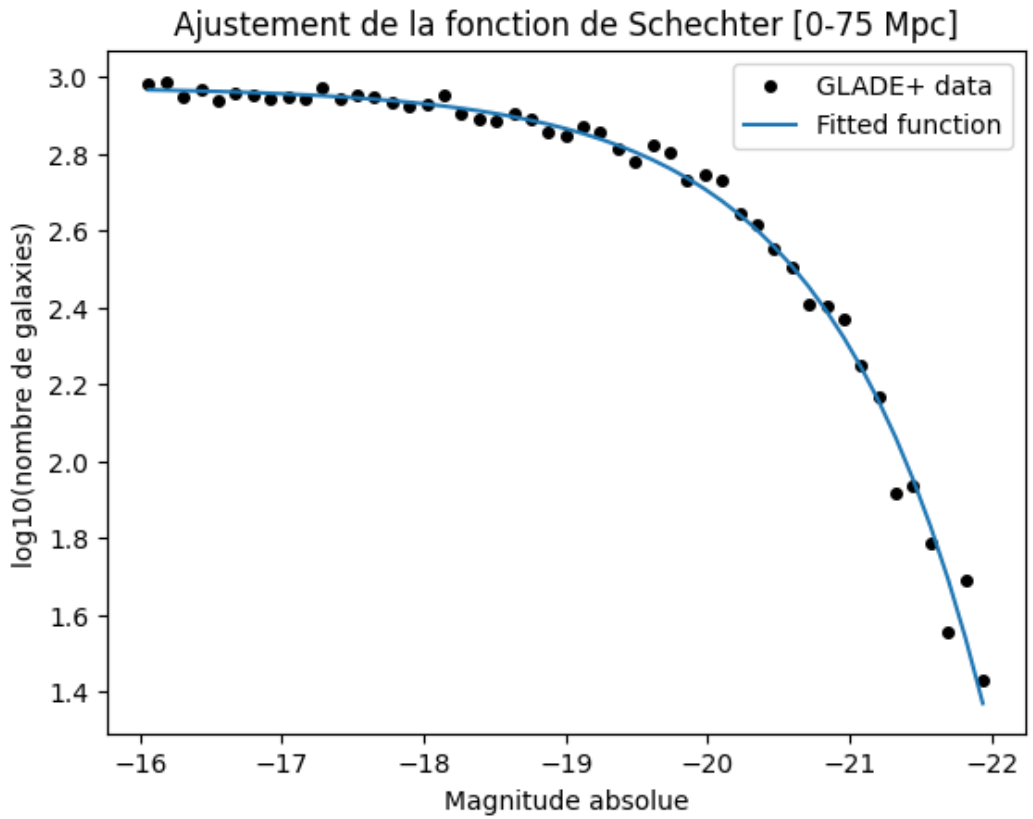
- **GLADE+ catalog** (Dálya et al. 2022):
  - An extended observational catalogue combining several real data sources
  - Provides precise positions and redshifts for nearby galaxies
  - Used for its completeness and real data, essential for testing the method on current datasets

- **Simulated catalogue** (David's Lightcone: Izquierdo-Villalba et al. 2019):
  - Catalogue based on cosmological numerical simulations
  - Allows testing the method on controlled data and anticipating future LISA detections

Validating the Method on Real Data

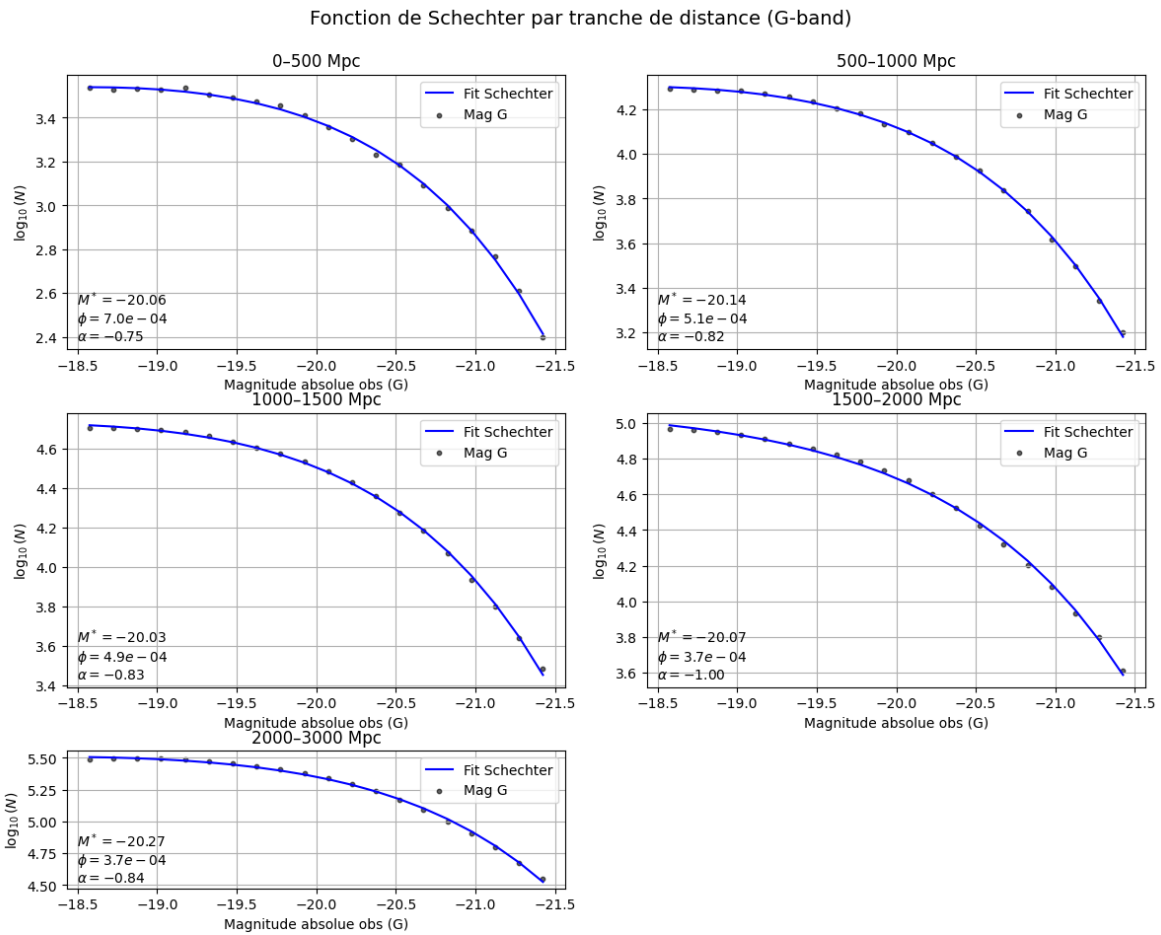
- Best-fit Schechter parameters derived from the **GLADE+ catalog** are consistent with the literature.

Source	ϕ^* [Mpc^{-3}]	α	M^*
This work (GLADE+)	4.71×10^{-3}	-1.00	-20.52
Dálya et al. 2022	$\approx 4.1 \times 10^{-3}$	-1.30	-21.02
Brozzetti. M. L. et al. 2024	$\approx 4.3 \times 10^{-3}$	-1.25	-20.9



Validating the Method on Mock Data

- The best-fit Schechter parameters derived from the **mock catalog** are smaller than those reported in the literature.
- This may be due to the assumptions or conditions under which the mock catalog was generated.



Conclusion

- GWs offer an independent way to constrain H_0
- Galaxy catalogues allow redshift estimation for dark sirens
- This method is adapted for future LISA detections

References I

- Abbott, B. P et al. (June 2016). "Properties of the Binary Black Hole Merger GW150914". In: *Physical Review Letters* 116. DOI: 10.1103/PhysRevLett.116.241102.
- Brozzetti, M. L. et al. (2024). "GLADEnet: A progressive web app for multi-messenger cosmology and electromagnetic follow-ups of gravitational-wave sources". In: *AA* 684, A44. DOI: 10.1051/0004-6361/202348073. URL: https://doi.org/10.1051/0004-6361/202348073.
- Dálya, G et al. (May 2022). "GLADE+ : an extended galaxy catalogue for multimessenger searches with advanced gravitational-wave detectors". In: *Monthly Notices of the Royal Astronomical Society* 514.1, pp. 1403–1411. ISSN: 1365-2966. DOI: 10.1093/mnras/stac1443. URL: http://dx.doi.org/10.1093/mnras/stac1443.

References II

 Izquierdo-Villalba, David et al. (Oct. 2019). "J-PLUS: Synthetic galaxy catalogues with emission lines for photometric surveys". In: *Astronomy amp; Astrophysics* 631, A82. ISSN: 1432-0746. DOI: 10.1051/0004-6361/201936232. URL: http://dx.doi.org/10.1051/0004-6361/201936232.