

Towards precision H_0

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Nikhef, Amsterdam

PAX-VI, Cascina
2019 May 27



H_0 with GW170817

Standard siren

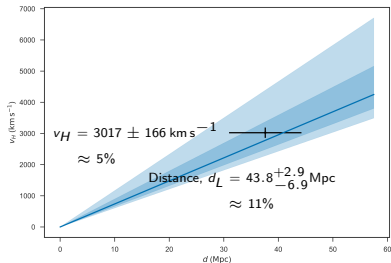
Independent of any distance ladder

GWs provided a direct measurement of the luminosity distance!

$$v_H \equiv zc \approx H_0 d_L$$

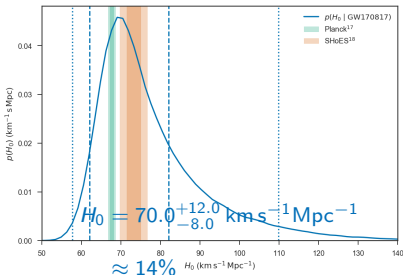
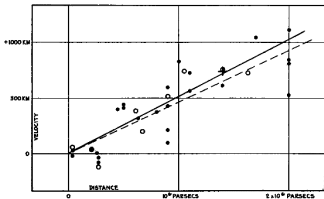
Redshift (recession velocity) came from host galaxy NGC 4993.

First plot in the GW Hubble diagram:



LSC-EPO

Edwin Hubble, *Proc. Nat. Acad. Sciences.* (1929)

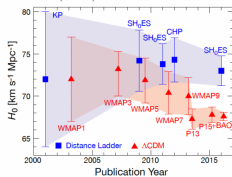


Abbott et al. *Nature* 551 #7678, 85-88 (2017)

Discrepancy in state-of-the-art measurements of H_0 !

Two contrasting methods applied on nearby and very distant cosmological scales

Freedman (2017)



Planck $\approx 0.7\%$
SHoES $\approx 2\%$

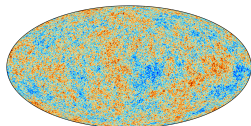
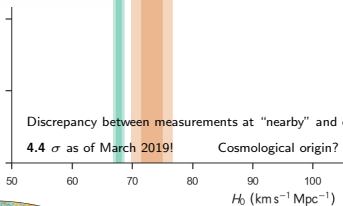
Standard candles

Cosmic distance ladder

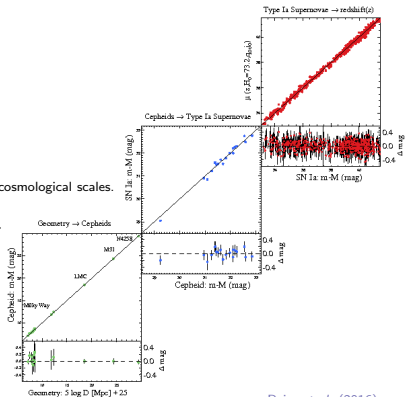
Discrepancy between measurements at "nearby" and cosmological scales.

4.4 σ as of March 2019!

Cosmological origin?

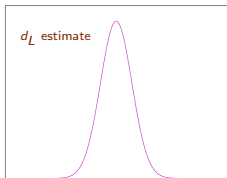


Planck collaboration (2015) + Λ -CDM

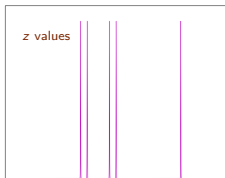


Reiss et al. (2016)

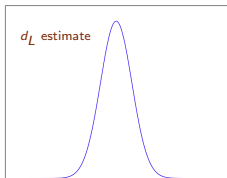
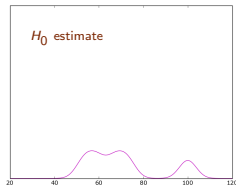
Independent events



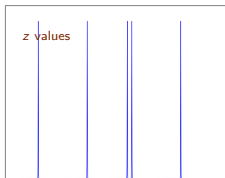
+



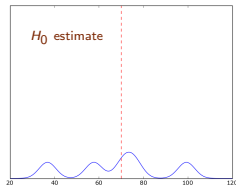
\Rightarrow



+



\Rightarrow



Different possible galaxies for single event

Multimodal H_0 estimate for each event

Combine information from all observed events \Rightarrow

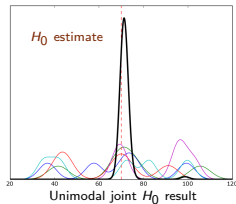


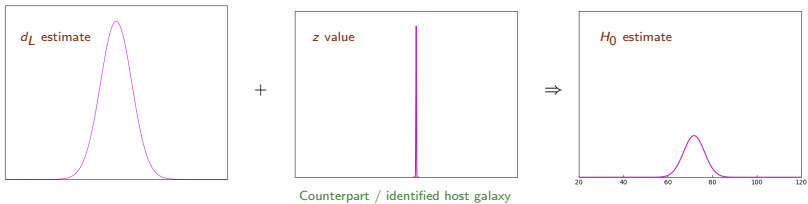
Schutz " H_0 -statistical" method

galaxy catalogues in absence of transient EM counterparts

applicable also for **binary black holes**

Schutz (1986)



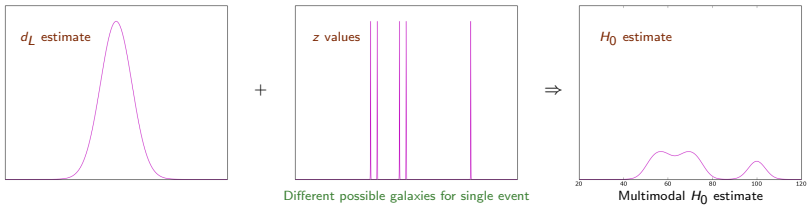


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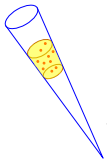
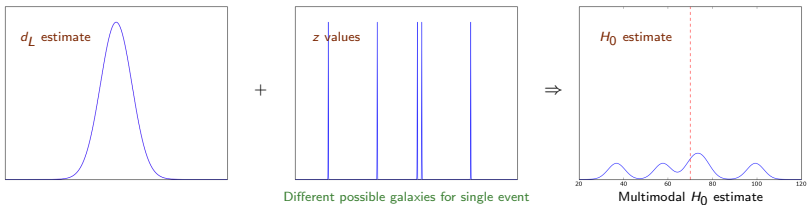


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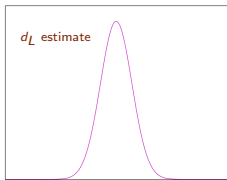
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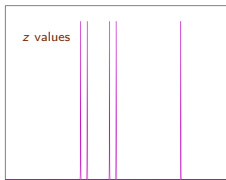
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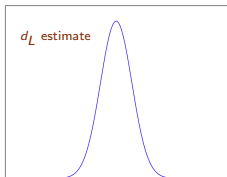
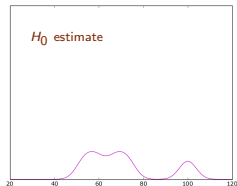
Independent events



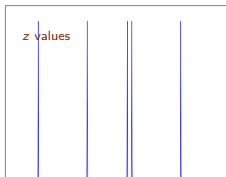
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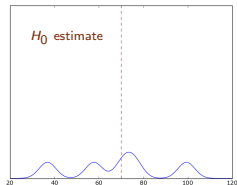
\Rightarrow



+



\Rightarrow



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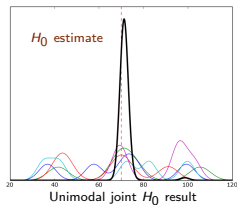


Schutz " H_0 -statistical" method

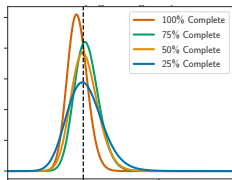
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Schutz (1986)



Schutz galaxy catalog / “ H_0 -statistical”: results on simulations

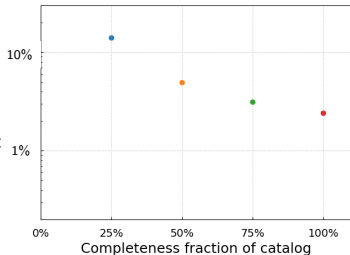
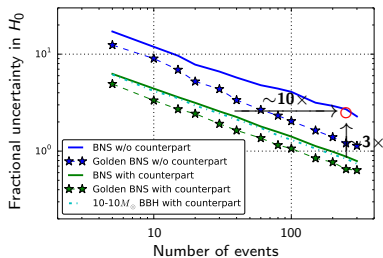


Statistical: **incomplete galaxy catalogue**

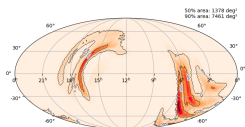
Account for galaxies absent in catalogue

Chen *et al.* (2018): counterpart & statistical

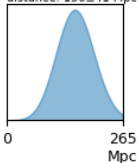
Gray *et al.* (in prep.) using `gwcs` codebase



Cosmology Working Group: Ajith, Brady, Chen, Dattier, Del Pozzo, **Fishbach**, Gair, Ghosh, **Gray**, Hendry, Holz, **Magaña-Hernandez**, Messenger, Qi, Samajdar, **Sur**, Van Den Broeck, Veitch, . . .

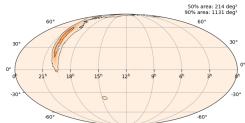


distance: 156±41 Mpc

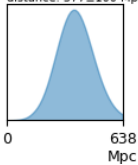


45,033 galaxies

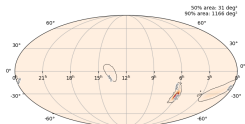
238,958 galaxies



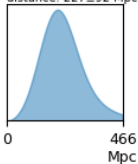
distance: 377±100 Mpc



13,960 galaxies



distance: 227±92 Mpc



17,197 galaxies

