Measuring H_0 with GW and SGL
&
Finesse simulation of mirror map of near-unstable cavity

Mengdi Cao (曹梦迪)

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- Beijing Normal University
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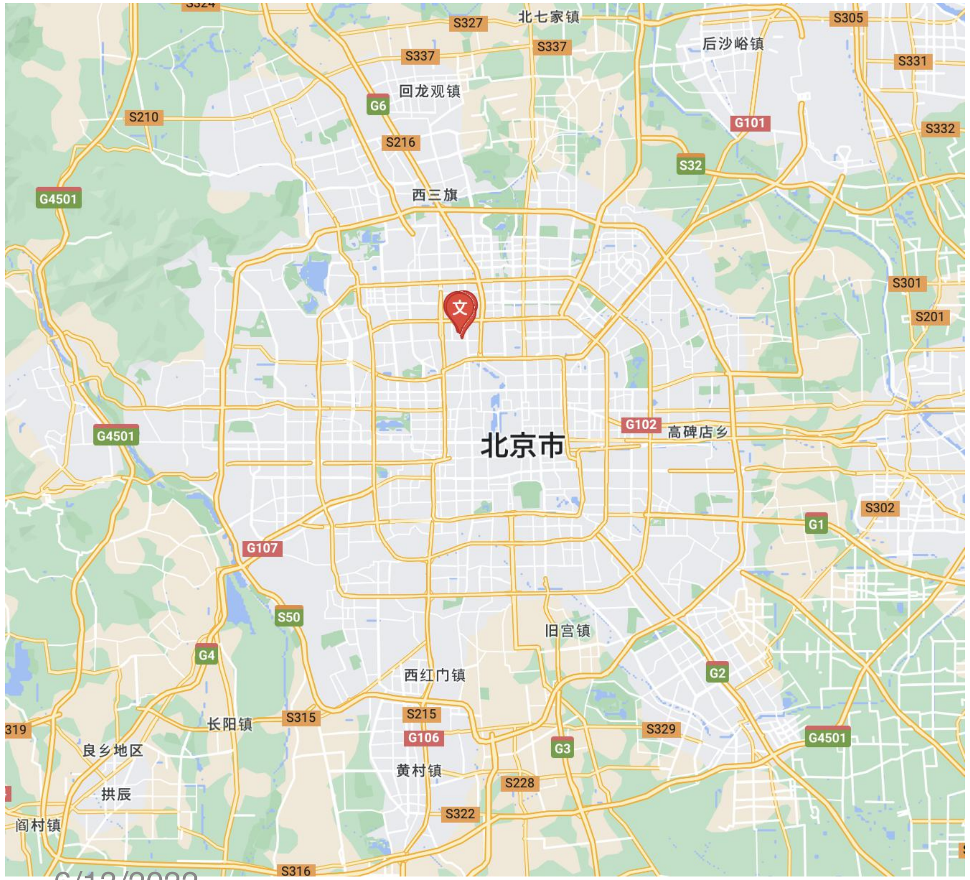
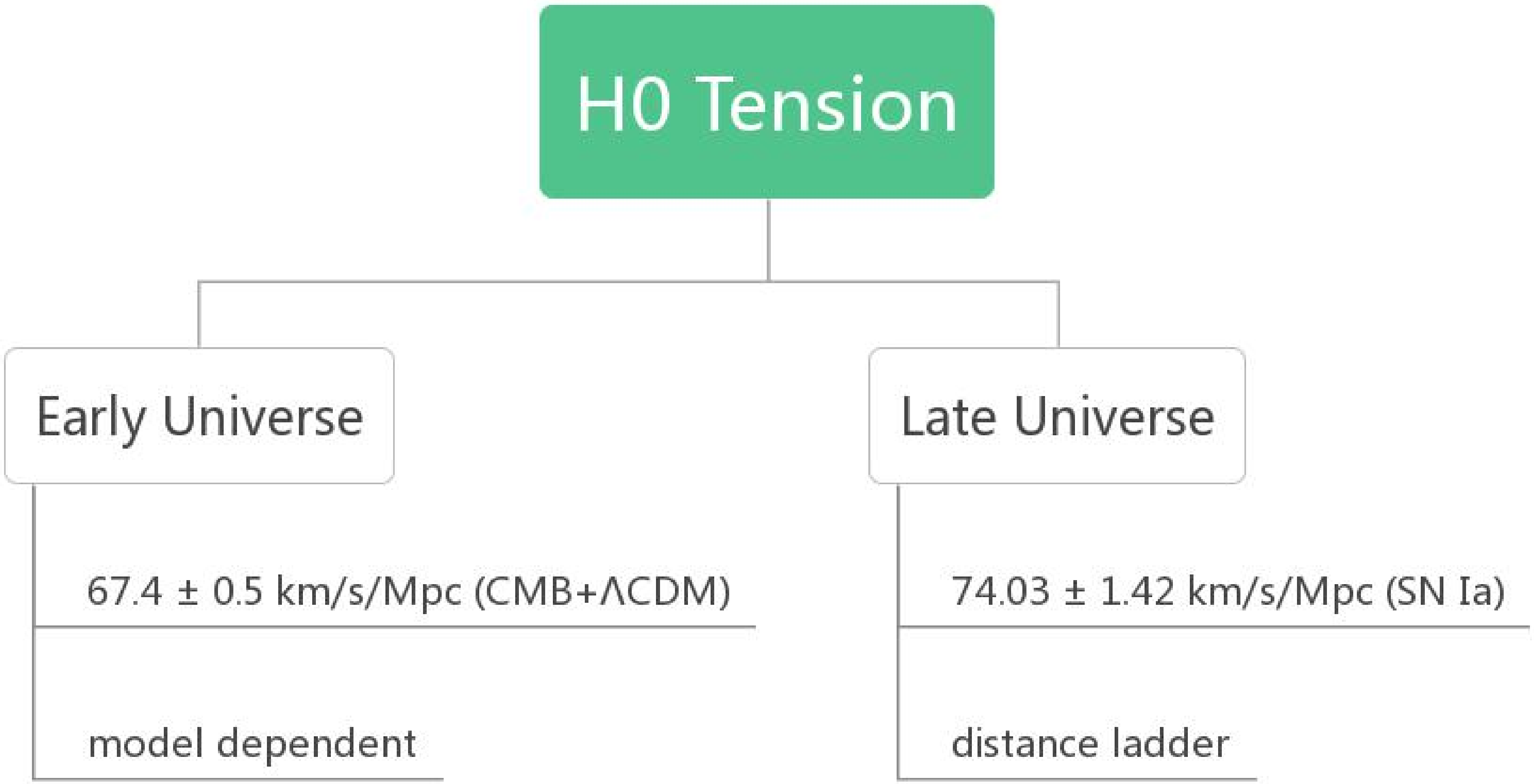


1. Measuring H_0 with Gravitational Wave (GW) and Strong Gravitational Lensing (SGL)

H_0 Tension


H0 Tension
Early Universe
Late Universe
67.4 ± 0.5 km/s/Mpc (CMB+ΛCDM)
model dependent
74.03 ± 1.42 km/s/Mpc (SN Ia)
distance ladder

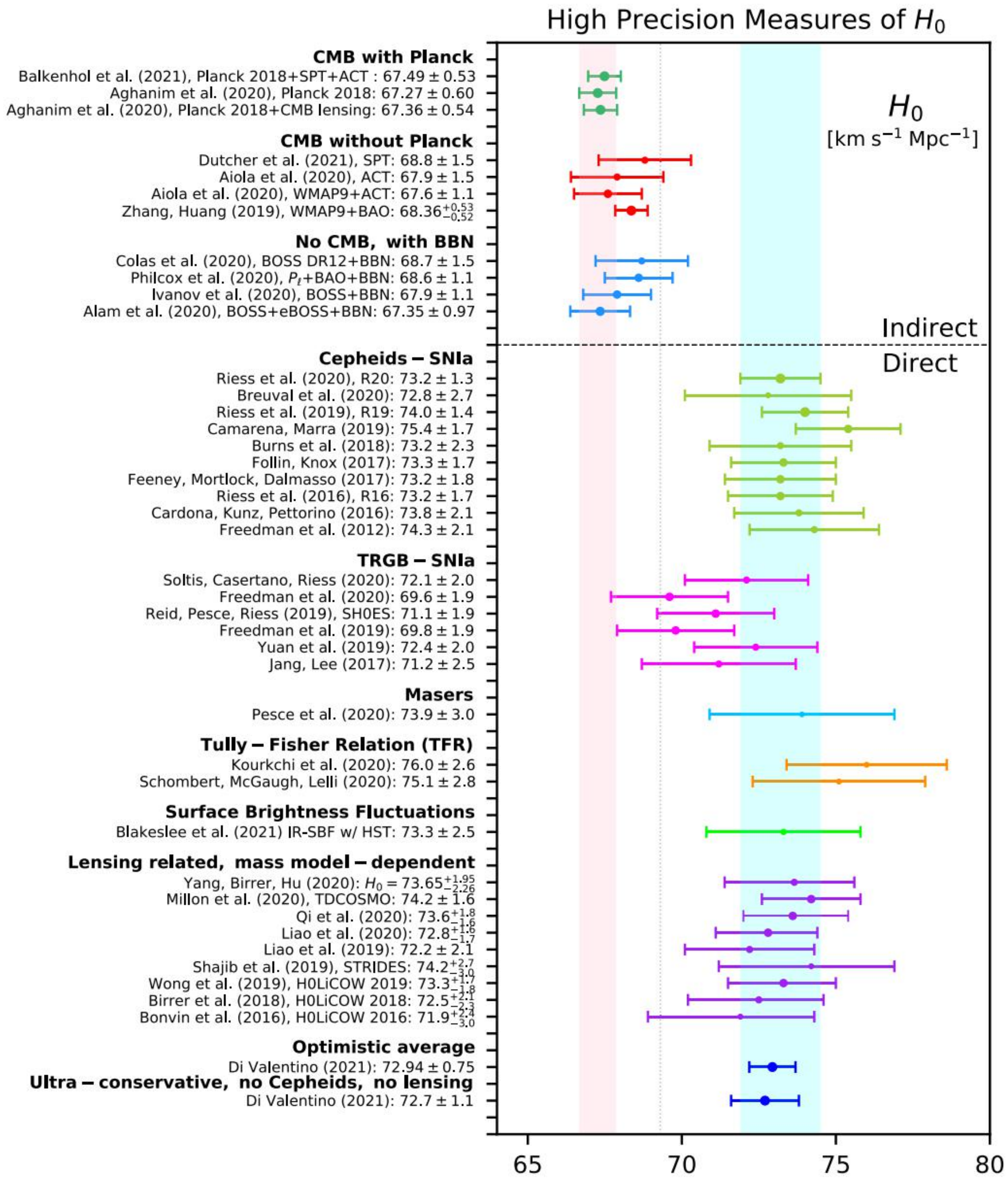
H_0 tension

Early Universe

67.4 ± 0.5 km/s/M

model dependent

N Ia)



(arXiv:2103.01183)

H_0 tension

- Discrepancy of Ω_k

Article | Published: 04 November 2019

Planck evidence for a closed Universe and a possible crisis for cosmology

Eleonora Di Valer

Nature Astronom

Abstract

The recent Plar
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Curvature tension: Evidence for a closed universe

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The curvature parameter tension between Planck 2018, cosmic microwave background (CMB) lensing, and baryon acoustic oscillation (BAO) data is measured using the suspiciousness statistic to be 2.5–3σ. Conclusions regarding the spatial curvature of the Universe which stem from the combination of these data should therefore be viewed with suspicion. Without CMB lensing or BAO, Planck 2018 has a moderate preference for closed universes, with Bayesian betting odds of over 50 : 1 against a flat universe and over

H_0 tension

Those cosmological tensions reflects that our understanding of the universe may be flawed under the framework of standard cosmological theory. At present, further confirming these inconsistencies in different ways is necessary. In particular, it is of importance to measure fundamental cosmological parameters in the late universe with some new and model-independent ways.

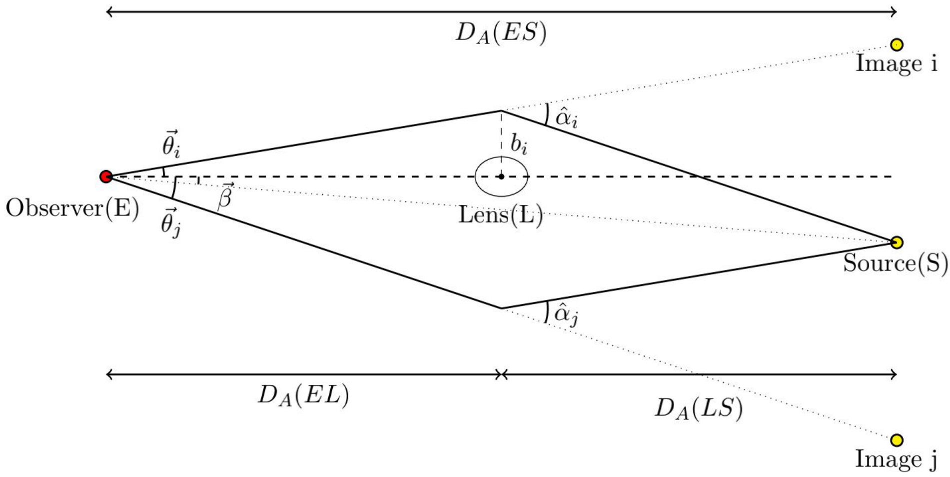
Methodology

Distance sum rule: $$\frac{d_l d_s}{d_{ls}} = \frac{1}{\sqrt{1/d_l^2 + \Omega_K} - \sqrt{1/d_s^2 + \Omega_K}}$$

$$d = H_0 D / c$$

Time-delay distance: $$D_{\Delta t} = \frac{c\Delta t_{i,j}}{\Delta \phi_{i,j}} = \frac{c}{H_0} \frac{d_l d_s}{d_{ls}}$$

$$\frac{D_{\Delta t} H_0}{c} = \frac{1}{\sqrt{1/d_l^2 + \Omega_K} - \sqrt{1/d_s^2 + \Omega_K}}$$



(JCAP 11 (2015) 033)

time delay measurements

Given Δt, $\Delta \phi$, d_l and d_s, we could give constraints on not only H_0 but also Ω_k model independently.

lens information

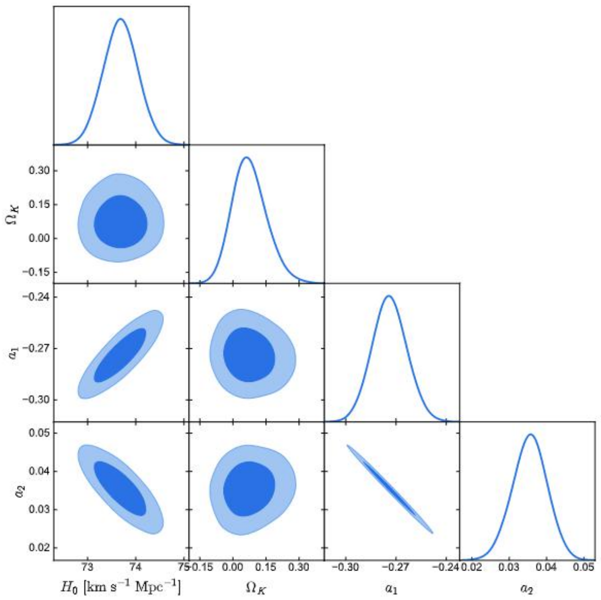
distance calibration from simulated GW

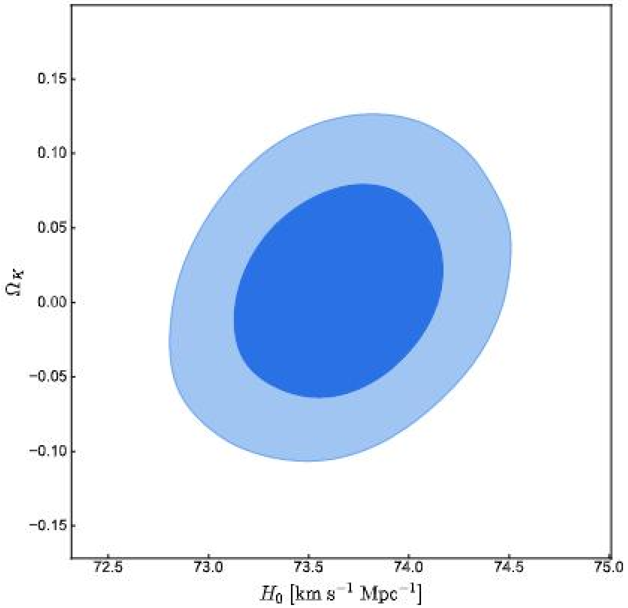
Results and discussion

- Constraints on H_0 and Ω_k

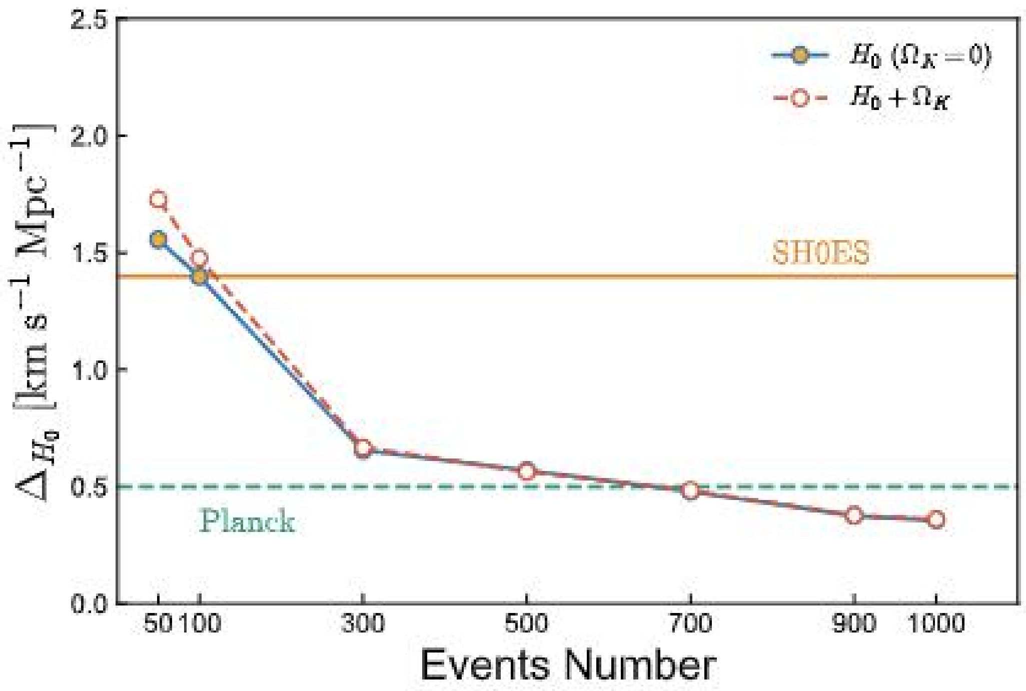
Table 2. Constraints on H_0, Ω_K, and the coefficients of third-order polynomial (a_1, a_2) with 1σ confidence level from SGLTD and GW data in the framework of distance sum rule.

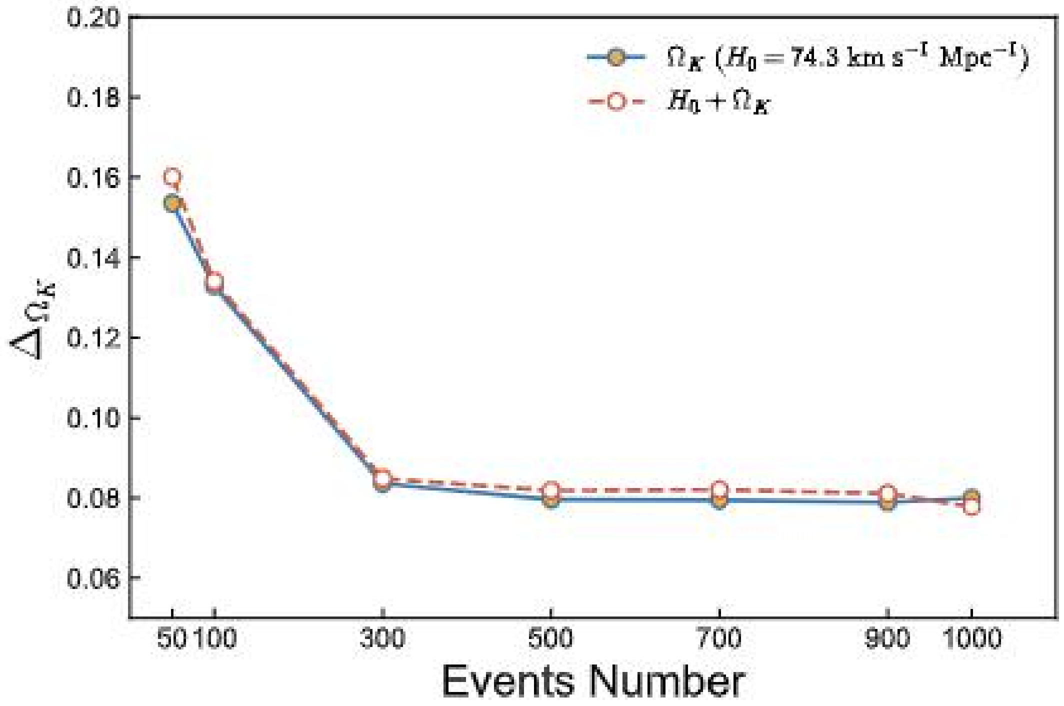
Data Set	H_0 (km s^{-1} Mpc^{-1})	Ω_K	a_1	a_2
6 observed SGLTD + 1000 simulated GW	73.69 ± 0.36	$0.076^{+0.068}_{-0.087}$	-0.274 ± 0.010	0.035 ± 0.005
	73.66 ± 0.36	0 (fixed)	-0.273 ± 0.010	0.035 ± 0.005
	74.03 (fixed)	$0.082^{+0.072}_{-0.087}$	-0.266 ± 0.006	0.032 ± 0.003
55 simulated SGLTD + 1000 simulated GW	73.65 ± 0.35	0.008 ± 0.048	-0.274 ± 0.010	0.0357 ± 0.0045





Results and discussion



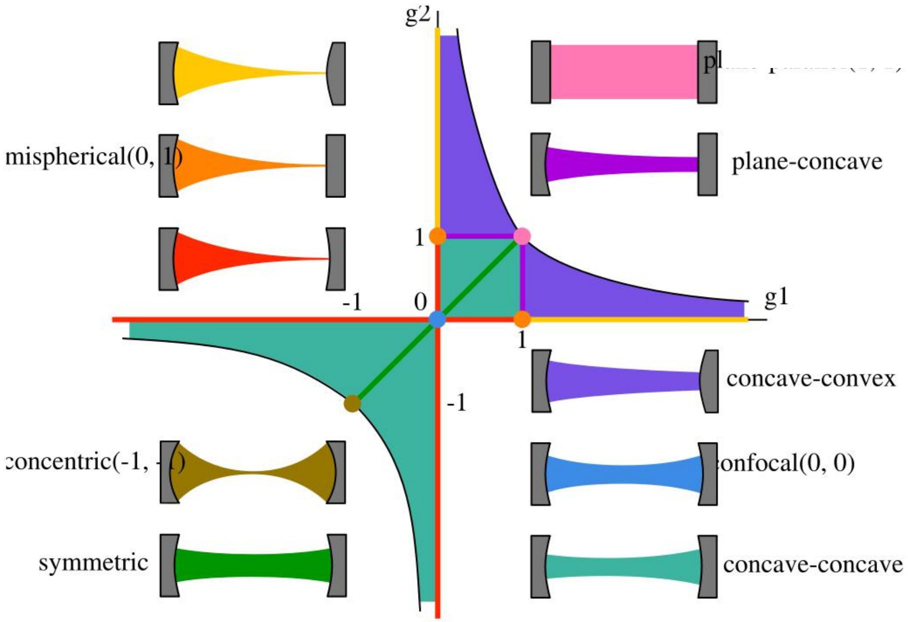


Conclusion

- We applied a model-independent way in constraining H_0 and Ω_k, by using simulated gravitational waves and strong gravtational lensing systems.
- The constraint precision for H_0 given by the combined 100 GWs can be comparable with the measurement from SH0ES collaboration. As the number of GW events increases to 700, the constraint precision of H_0 can exceed that of the Planck 2018 results.
- The constraints on Ω_K improve significantly with the increase of GW events from 50 to 300, but it is almost no longer improved after 300 GW events. Such a trend also exists in the constraints on H_0.

2. Finesse simulation of mirror map of near-unstable cavity

Near-unstable Cavity



https://doi.org/10.1103/PhysRevD.97.022001

Feasibility of near-unstable cavities for future gravitational wave detectors

Haoyu Wang[1,2,*] Miguel Dovale-Álvarez[1], Christopher Collins[1], Daniel David Brown[1], Mengyao Wang[1], Conor M. Mow-Lowry[1], Sen Han[2], and Andreas Freise[1]

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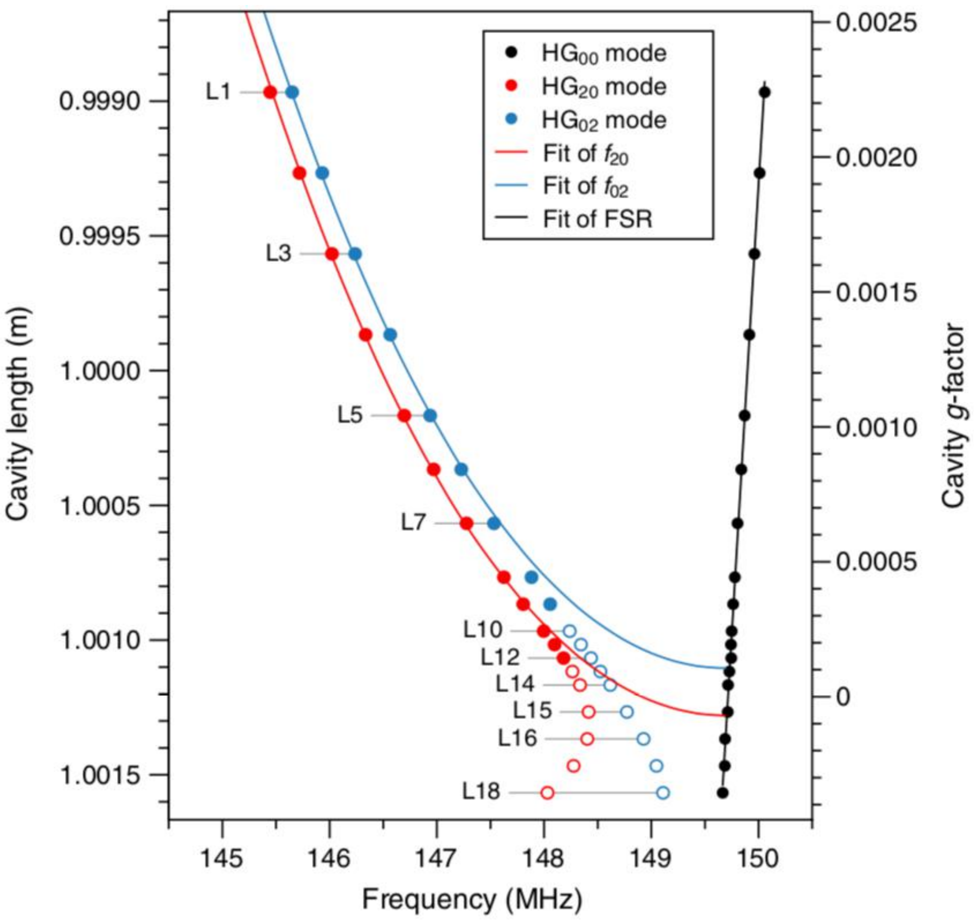
Near-unstable cavities have large beam spots to reduce coating thermal noise.

Problems:

- Mode bunching
- Easily affected by mirror defects
- ……



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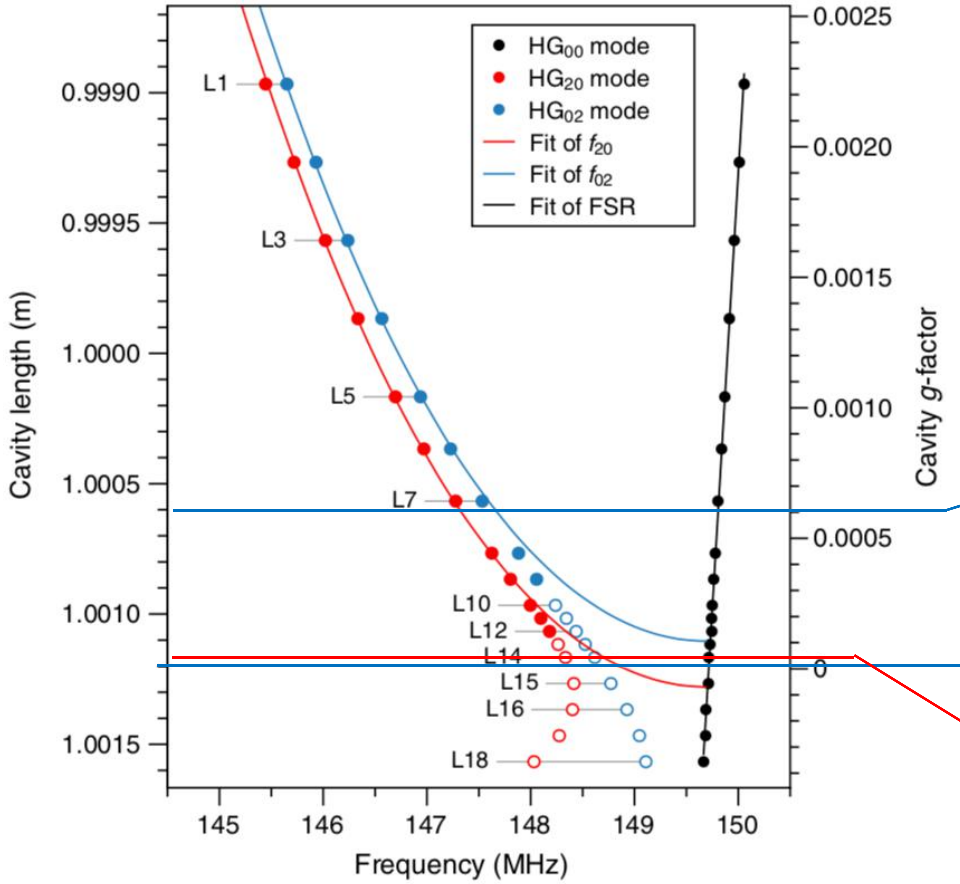
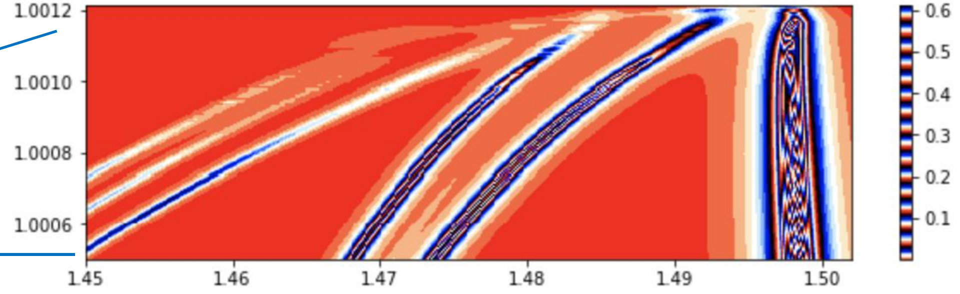
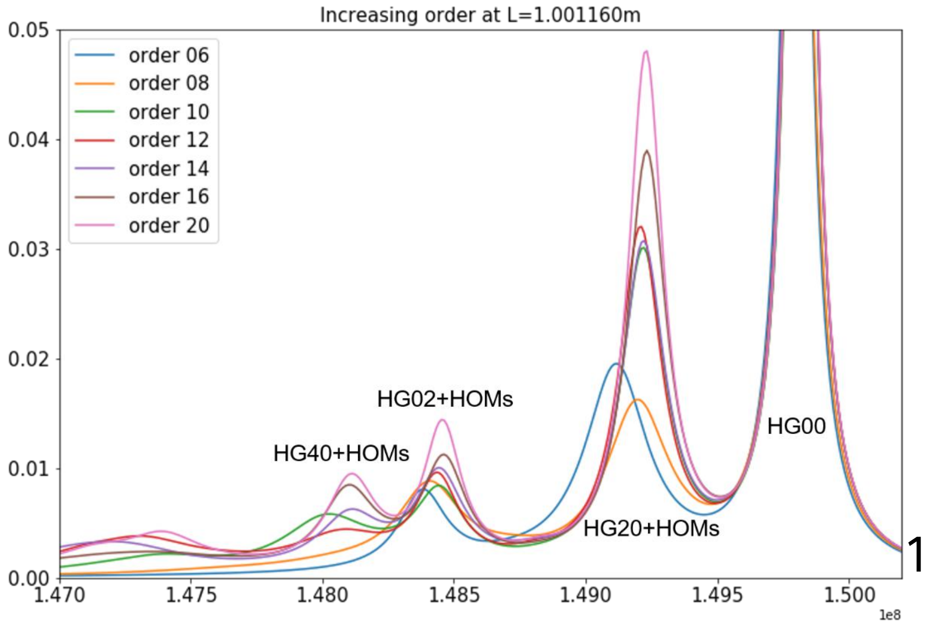
We use FINESSE to derive resonances and shapes of the higher order modes and the 00 mode. The goal of the simulation is trying to understand mode frequency deviations observed in the experiment.

https://doi.org/10.1103/PhysRevD.97.022001



The maximum HOM order taken into account for calculation here is 10.





Resonances using different maximum order at one cavity length

The maximum order of HOMs for calculation does matter very much.

We need to do more simulations later to explore higher order modes behavious when the cavity is gradually pushed to the edge of geometric stability.

Future Plan

- Finish the simulation research with Haoyu-san.
- Get familiar with the research people are doing in Ando Lab
- Find what I'm interested in and start my research in Ando Lab
- ……

Thanks for listening!