Cosmology using 1-loop EFT power spectrum for HI intensity mapping

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Cosmological constraints from the power spectrum and bispectrum of 21cm intensity maps

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Check it Out →

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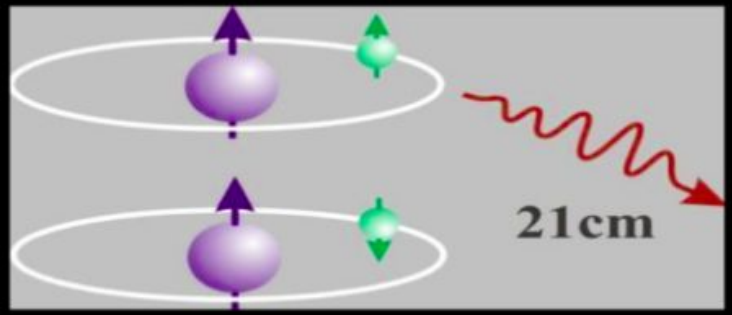
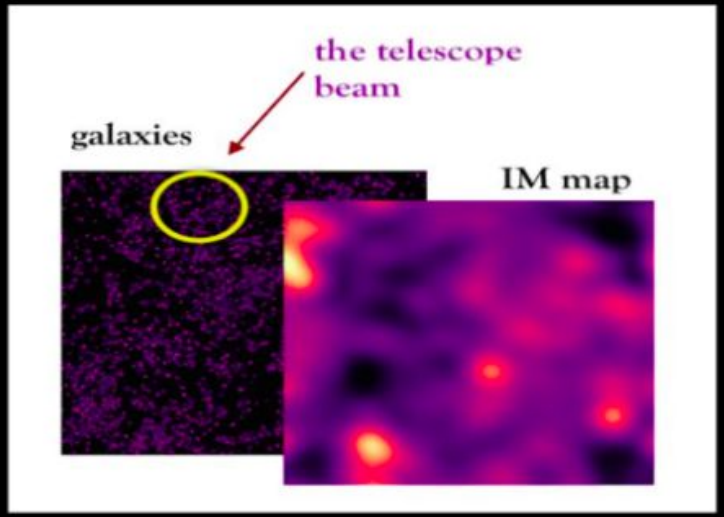
HIRAX (The Hydrogen Intensity Real-time Analysis eXperiment)

HIRAX is **radio telescope** array that will map nearly all of the **southern sky** in **radio continuum** and neutral **hydrogen line emission** over a frequency range of **400 - 800MHz**

z	[0.77,2.55]
D_{dish} (m)	6
N_{dish}	1024
D_{max} (km)	0.25
S_{area} (deg^2)	15000
t_{total} (hours)	17500

What is HI Intensity Mapping ?





HI signal is the 21cm (1420 MHz) line emission from the
Spin flip of the Neutral Hydrogen.

$$1 + z = \frac{\lambda}{21cm}$$

IM technique: is looking at the total intensity instead of counting galaxies.

- Integrated emission in each pixel, HI intensity map (like the CMB).
- Large pixels: joint emission from multiple galaxies instead of resolving them.
- Allows to probe large volumes.

HI power spectrum model

- We need to access non-linear scales to improve the signal,
- We use the 1-loop EFT to do this. [**Arxiv 2106.09713**]

The expression for the EFT (effective field theory) one-loop redshift space power spectrum is given as follows,

$$P^{\rm HI}_{\rm EFT} = P^{\rm HI}_{1-{\rm loop}} + (\alpha_0 + \alpha_2\mu^2 + \alpha_4\mu^4)(k/k_*)^2 P^{\rm Zel}_{\rm cb} + N_0 + N_2(\mu k)^2 + N_4(\mu k)^4$$

Where, $P^{\rm HI}_{1-{\rm loop}} = P^{\rm HI}_{11} + P^{\rm HI}_{22} + P^{\rm HI}_{13}$

N_n : stochastic contributions and small-scale velocities (FoG effects)

α_n : handful of counterterms

$$P^{\rm HI}_{\rm EFT,obs} = \frac{H}{H^{\rm fid}} \frac{D_{\rm A}^{\rm fid\ 2}}{D_{\rm A}^2} P^{\rm HI}_{\rm EFT}$$

- Foreground radial avoidance

Foreground affects the long-wavelength line of sight modes. We exclude these modes using a cut off,

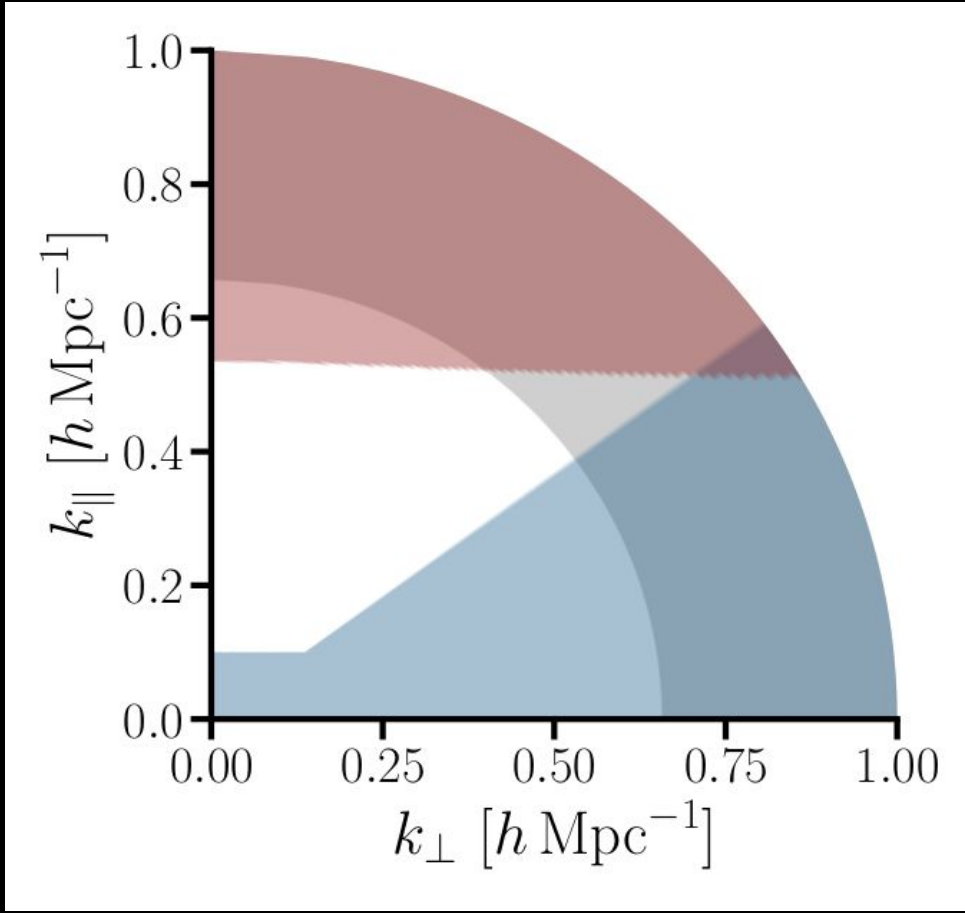
$$k_{\parallel,\mathrm{fg}} = 0.01h\,\mathrm{Mpc}^{-1}$$

- Foreground wedge avoidance

We exclude all modes lying in the foreground wedge by applying the following condition,

$$k_{\parallel} \geq A_{\mathrm{wedge}}\, k_{\perp} \quad \text{such that} \quad A_{\mathrm{wedge}} = \frac{\chi(z)\, H(z)}{c(1+z)} \sin[0.61 N_{\mathrm{w}} \theta_{\mathrm{b}}]$$

Available modes [Non shaded region of the plot]



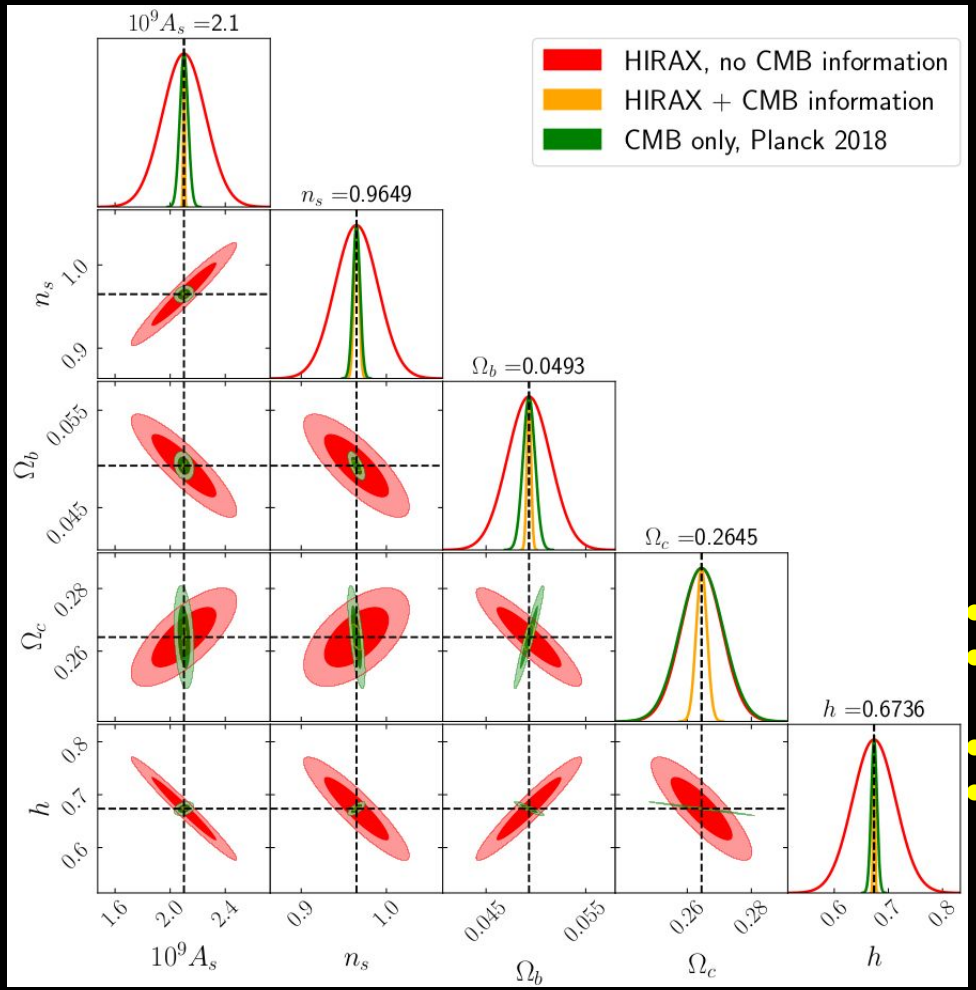
Courtesy: N. Sailer et al.

Methodology of Forecast : FISHER FORMALISM

$$F_{ij} = \sum_{k_f \leq k} \int_{-1}^{1} \frac{d\mu}{2} \frac{\partial P^{s}_{\rm HI}}{\partial \theta_i} \frac{\partial P^{s}_{\rm HI}}{\partial \theta_j} \frac{1}{\Delta P^2}$$

$$\Delta P^2 = \frac{4\pi^2}{V\, k^2\, \Delta k} \left[P^{s}_{\rm HI} + P_N\right]^2$$

Result



Cosmological parameters:
A_s : Scalar amplitude
n_s : Scalar spectral index (slope)
Ω_b : Baryon density parameter
Ω_c : Dark matter density parameter
h : Hubble parameter

- Marginalisation over bias and nuisance parameters
- Hirax breaks degeneracies between some parameter not all.
- Error on Ω_c is reduced
- CMB planck 2018 constraints can be improved if we add non-linearity (EFT)

Conclusion:

- **Adding the power spectrum of Hirax, up to non-linear scales, to the CMB improves all parameters while it breaks degeneracies between some parameters. Moreover it significantly improves the Ω_c constraints.**

Ongoing Works:

- **Constraining the growth rate;**
- **Constraining dark energy models;**
- **Adding Bispectrum to break degeneracy in some parameters;**
- **Paper.**

Thanks for your attention !

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