# Impact of astrophysical scatter on the $[H\ I]_{21cm}$ bispectrum

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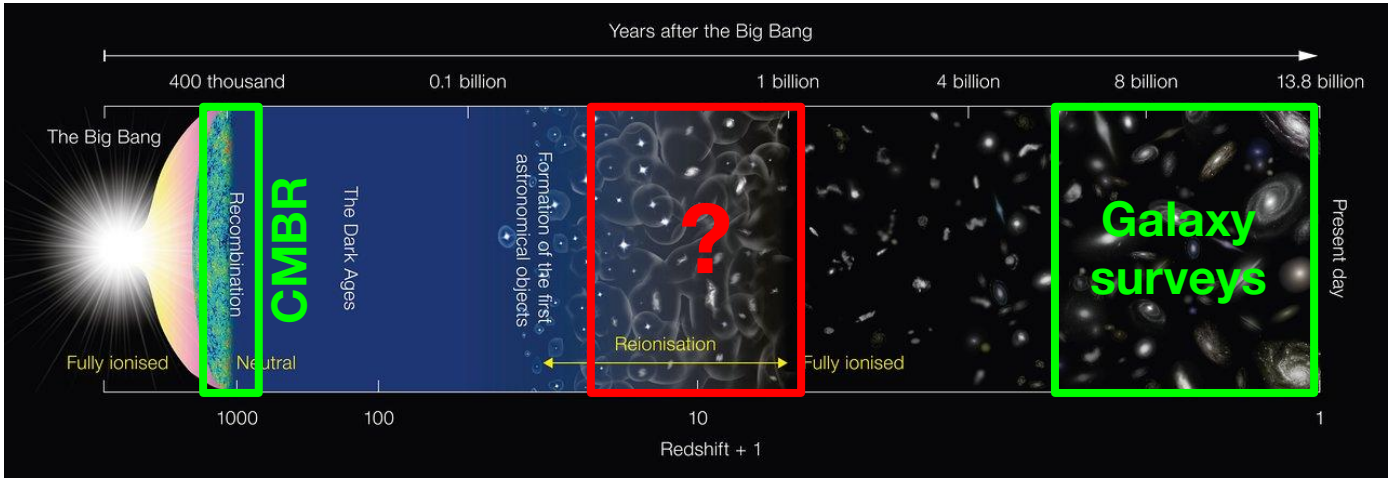
# The Epoch of Reionization (EoR)



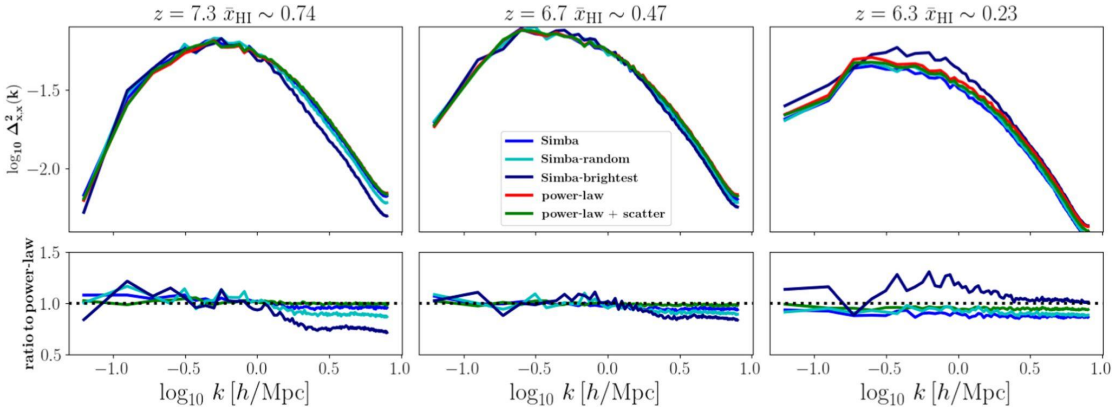

Credit: NAOJ

- First luminous sources (galaxies) were formed
- Ionizing radiation from the luminous sources reionized the neutral IGM

Star-formation can be stochastic in nature e.g. bursty star-formation

**How variability in the star-formation rate (astrophysical scatter) affects reionization of the IGM?**

# Impact on power spectrum




Hassan et al. 2022, *ApJ*, 931, 62

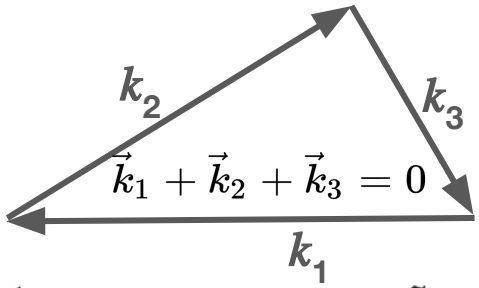
The ionization power spectrum is mostly unaffected, when astrophysical scatter is included in modelling reionization

- Ionization field is not directly observable, unlike the brightness temperature fluctuations of the $[\mathrm{H\ I}]_{21\mathrm{cm}}$ signal
- $[\mathrm{H\ I}]_{21\mathrm{cm}}$ signal is known to be highly non-Gaussian and astrophysical scatter might introduce additional non-Gaussianities

# [H I]$_{21cm}$ bispectrum

[H I]$_{21cm}$ signal is known to be highly non-Gaussian and astrophysical scatter might introduce additional non-Gaussianities

**Higher order statistics such as bispectrum can capture non-Gaussianities in the [H I]$_{21cm}$ signal**




$$B_m(\vec{k}_1, \vec{k}_2, \vec{k}_3) = \frac{1}{N_{\rm tri} V} \sum_{[\vec{k}_1+\vec{k}_2+\vec{k}_3=0]\in m} \tilde{\Delta}T_b(\vec{k}_1)\tilde{\Delta}T_b(\vec{k}_2)\tilde{\Delta}T_b(\vec{k}_3)$$

# Simulations of the [H I]$_{21cm}$ signal

Usual reionization source model:

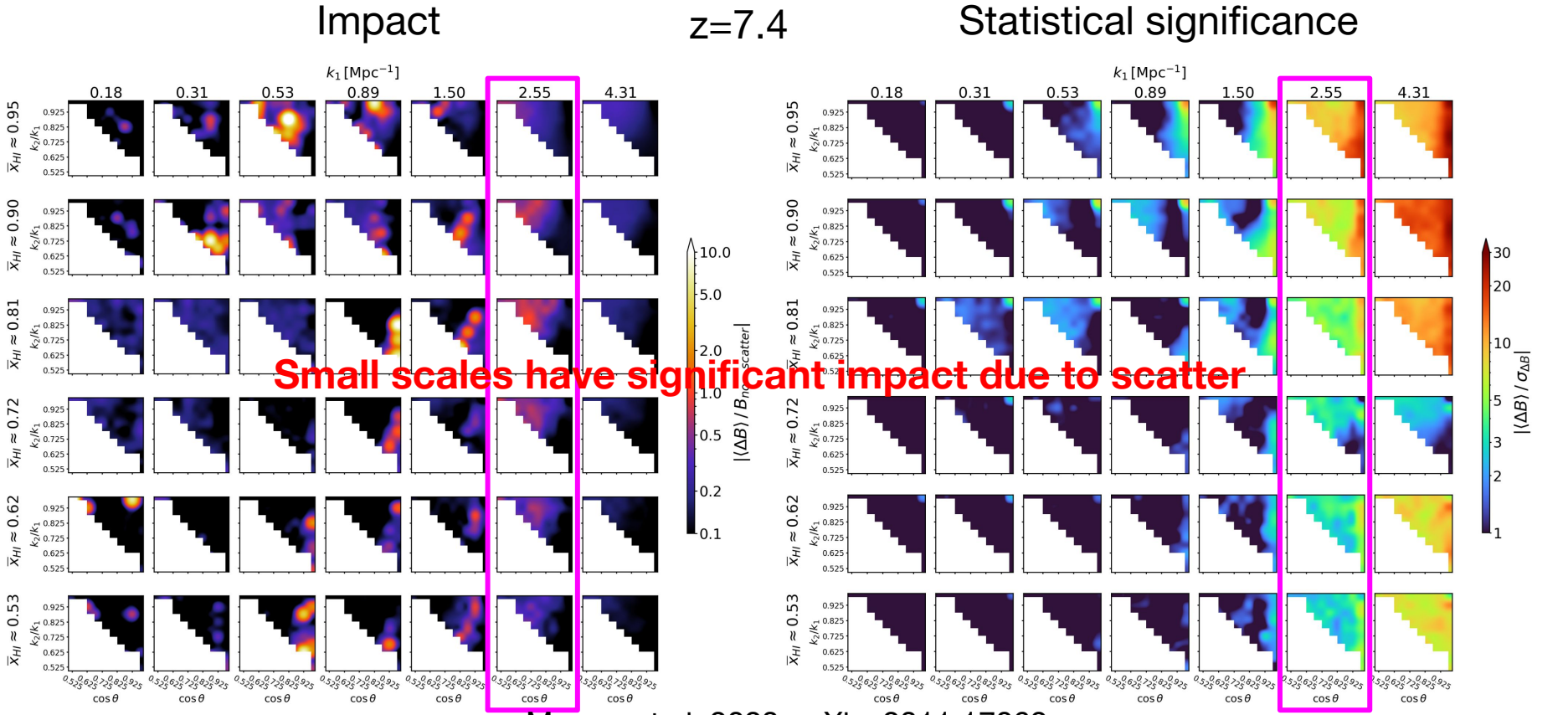
$$N_\gamma \propto \overline{\mathrm{SFR}}(M_h, z)$$

Simplistic model for astrophysical scatter:

$$N_\gamma \propto \overline{\mathrm{SFR}}(M_h, z) + \text{Log-normal scatter}$$

We generate 50 realizations of the [H I]$_{21cm}$ signal for each of six neutral fractions at z=7.4 that we considered (a total of 300 simulations were done)

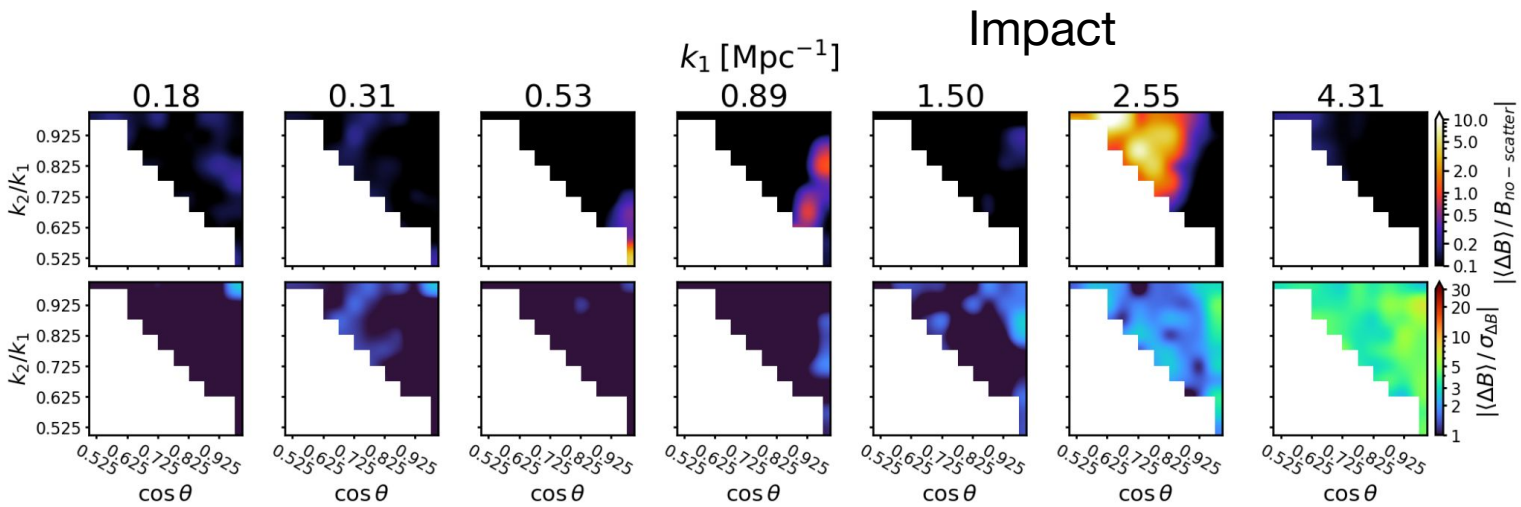
# Impact of scatter on the [H I]$_{21cm}$ bispectrum




Murmu et al. 2023, arXiv: 2311.17062

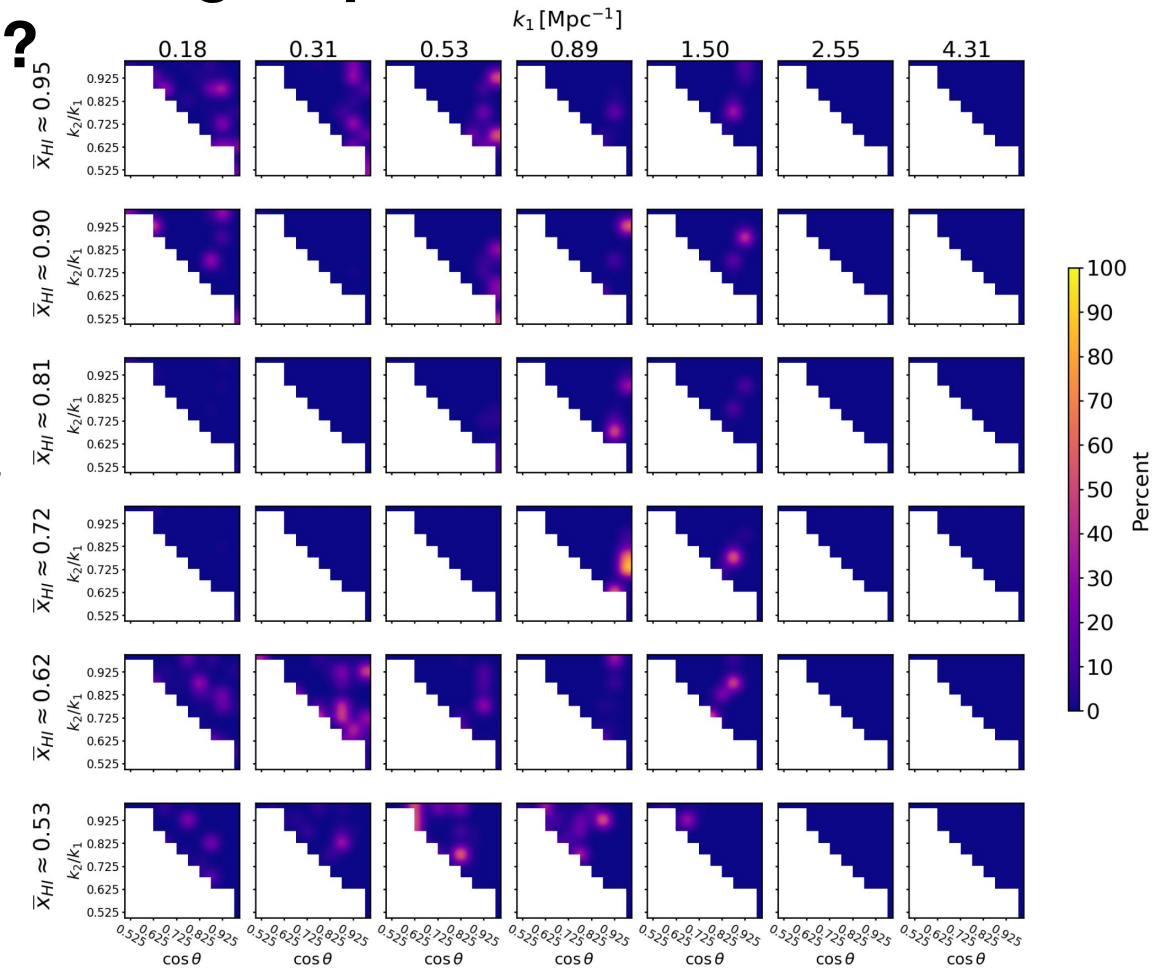
# Impact of scatter at z=10, $x_{HI}$ ~ 0.8

Additional 50 realizations were simulated

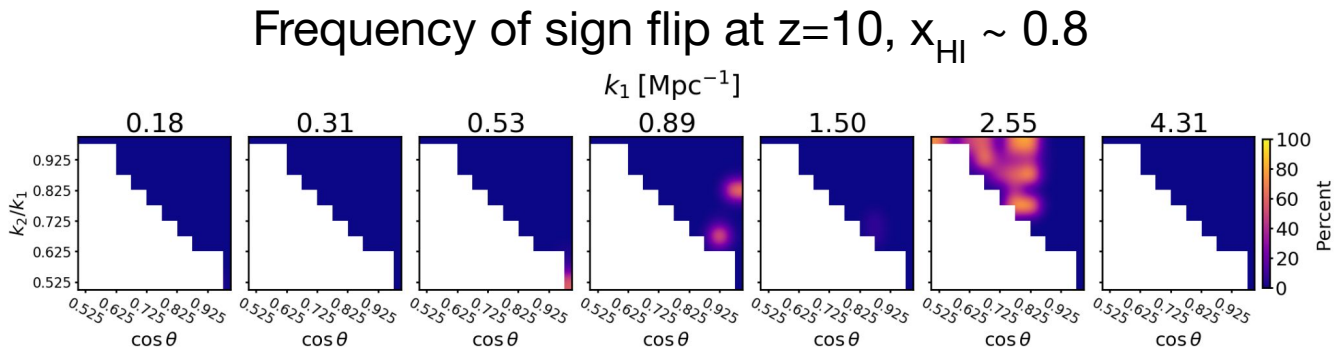


# Can scatter in SFR induce sign flip in $[\mathrm{H\ I}]_{21\mathrm{cm}}$ bispectrum?

Frequency of sign flip at z=7.4

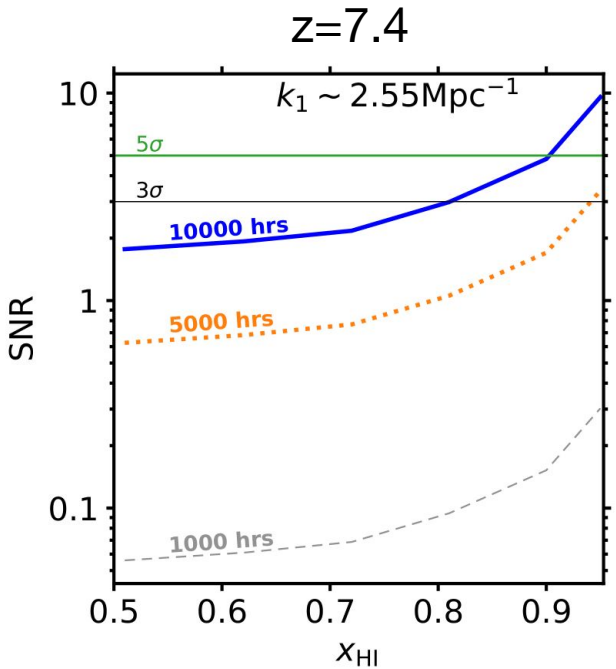


# Can scatter in SFR induce sign flip in $[\mathrm{H\ I}]_{21\mathrm{cm}}$ bispectrum?




**At small-scales frequency of sign flip can be significant**

# Detectability

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Optimistic scenarios can be adopted which observes for a fixed duration per year (e.g. 1000 hrs/year)

This can be extended for a couple of years after SKA1-Low is operational

# Future scope

- How halo-mass dependent scatter affects cosmic reionization
- Impact of astrophysical scatter on the cross-correlation of $[\mathrm{H\ I}]_{21\mathrm{cm}}$ and $[\mathrm{C\ II}]_{158\mu\mathrm{m}}$, CO LIM signals
- Incorporate density dependent recombination
- Other sources of reionization can be included
- Line-of-sight (anisotropies), such as redshift space distortion and light-cone effect might affect the impact of scatter

Thank you!