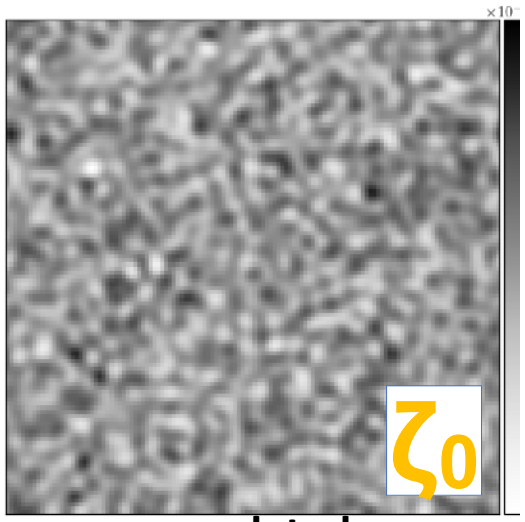
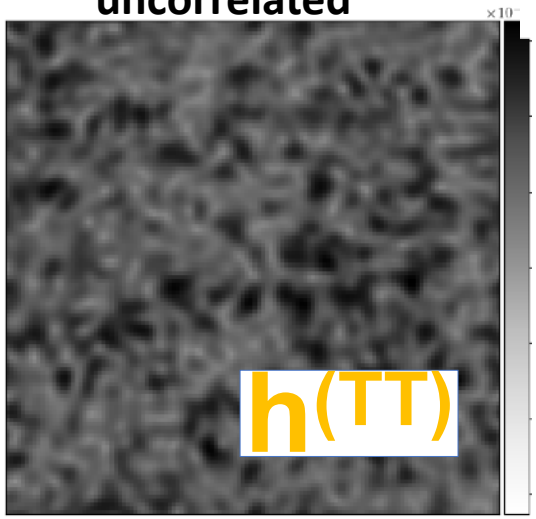
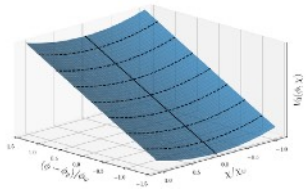
GRF from V0

scaling √r ~4 √ε0



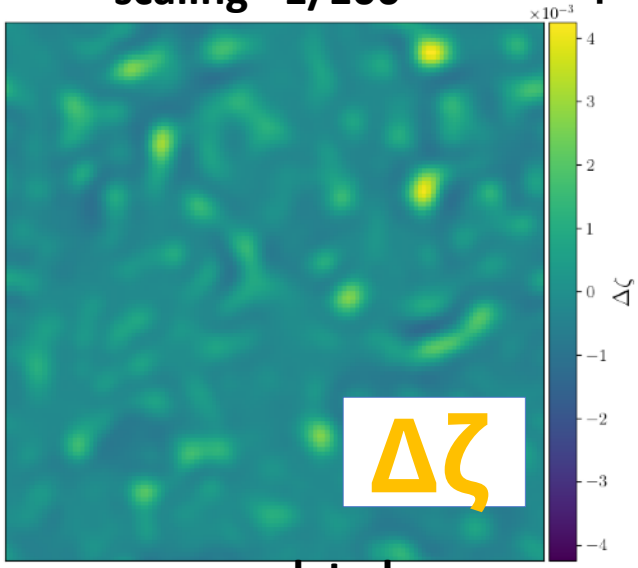
uncorrelated



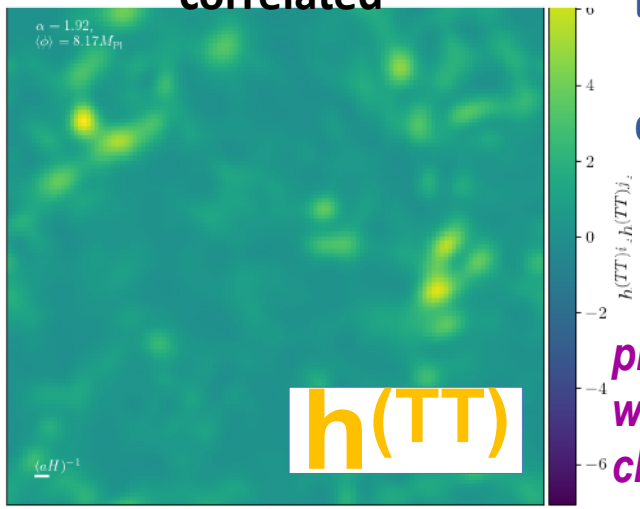


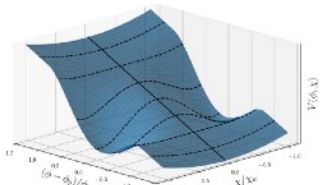
pinG from ΔV

scaling ~1/100



correlated

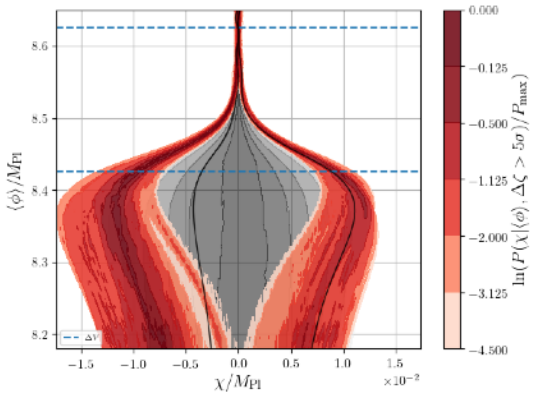




GRF controlled by ε0

cf

pinG controlled by instability strength



strong frozen pinG GW enter horizon then stream to a stochastic background, "tunable" GW frequency < 30 GHz, down to ~ 10^{-20} Hz

ζ_0 (CMB) ~$10^{-4.3}$

PBH target is Δζ > .01 to .1

pinGponGs less radical than PBHs, which are super-strain ponGs, clustered ponGs near proto-PBHs

Δζ >1: diffusion > drift
=> coherent Hc emerge from Δζ < 1

pinGponG ζ + GW

via instabilities, strained fields + hysteresis

emergence from fluctuation dominance via instability coherent H_c where ζ < 1

XYZ are ongoing unstable
gravitational collapse is $k_X k_Y k_Z$ instability => BH

just as cosmic web of XYZ in various components, DM, B, ν, γ

so cosmic superweb in XYZ, inflaton, & transverse field degrees of freedom
aka other dimensions =? 11D Sugra ~ string theory

my favourite Planck figures:

quadratic power maps for ζ_0 $h^{(TT)}$ isocons

linear ζ_0 Wiener maps + flucs from CMB T,E

\+ ***current & projected landscapes SO, Litebird, S4 for ζ_0 $h^{(TT)}$***

general: full differential lattice field simulations, can be fully encoded in stochastic framework $\phi = \phi c + \phi f$, communicate across $k_c(x_c) = Hc(\phi_c)$, general inflaton and isocon and TT strain (aka gravity wave) fields

$$d\zeta = -d\alpha\,(\varepsilon-\varepsilon_c)/\varepsilon_c \sim H_c/\sqrt{\varepsilon_c}\,M_P = \mathrm{sqrt}(d\sigma^2_{\zeta\zeta})\,GRD$$

$$dh^{TT} = \mathrm{sqrt}(d\sigma^2_{hh})\,GRD \sim H_c/M_P$$

f + f* => c fusion of fluctuations into frozen-out condensate $k< k_c(x_c)$ = BEC Jeans instability

c-instability $m_{\phi\phi}^2 < 0$ c + c* fission of the c-trajectories,

elastic stretching and relaxation, inelastic creates $d\zeta/d\alpha$

via flow from action to entropy

TT stress follows, hence GW follow

$\sim 2/M_P^2$ Green-fn * Π^{TT} (constrained)

$h^{TT} = h^{TT}$ (free) + h^{TT} (constrained)

CMB BE from Early Universe coherent Field-Strains: generation of spatially intermittent Gravity Wave and Entropic-Scalar coupled Condensates **BE in k-space ≡ UQ in k-space, known since 93 for GW**

Planck 2018 X inflation: TTTEEE lowL Epol + CMBlens + BK15 BB + *BAO*

derive **Veff(ϕ) & H(α) = Hc(ϕc) effective action/ entropy $S_G(\phi)$ acceleration ε(α) $S_K(\phi)=2\varepsilon S_G$ $= dS_G/d\alpha$ ~(ζ-spec)$^{-1}$ entropic luminosity per efold. reveals S_G**

CMB TT power L~ 20-30 dip **=> ζ-Spectrum k-dip @2σ~3bit; *lowL map anomalies ~3bit; cold spot ~15bit***

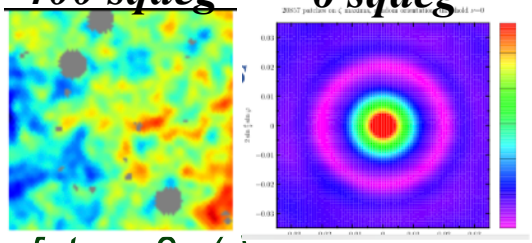
uniform n_s=0.9669±.00367 ⇒ future ±.002 SO

12-knot fit from k~ .008 to .3 uniform n_s is perfect

the ***ζ*-Webskys**

<ζ|TE> *400 sqdeg*

<ζ|ζpk> *6 sqdeg*



future 2σ(r)

SO 0.006
S4 0.001
Litebird 0.002

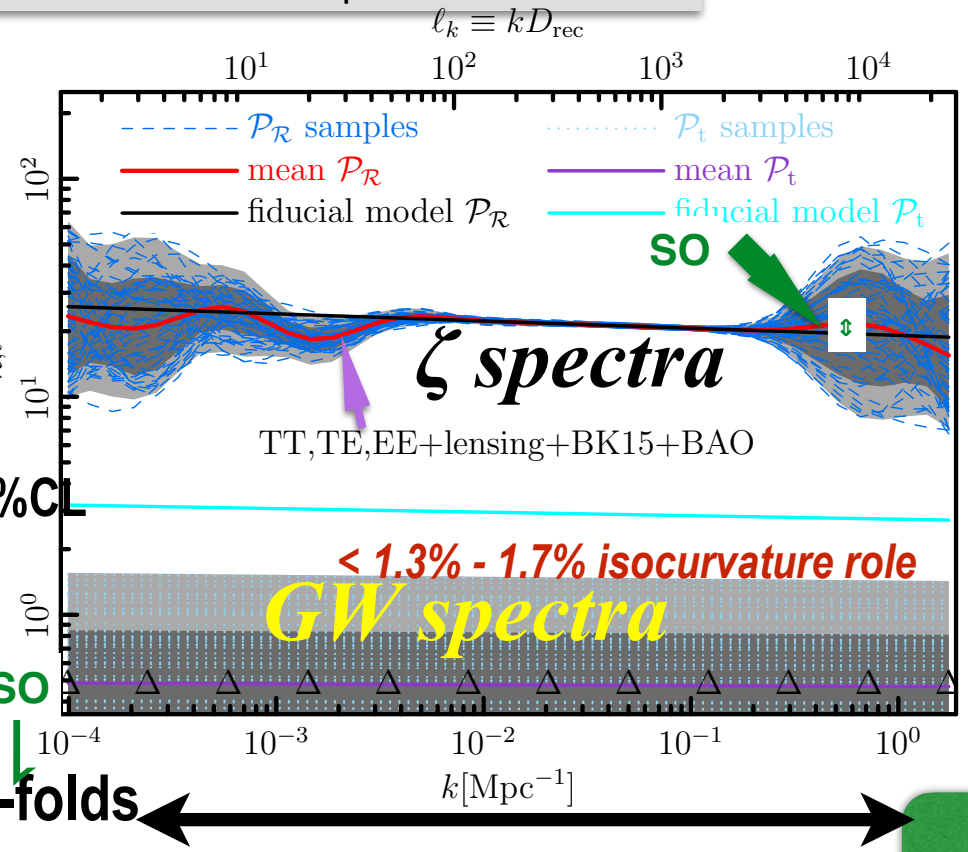
r<.069 95%CL

uniform n_s r<0.04

Litebird

SO

9 e-folds



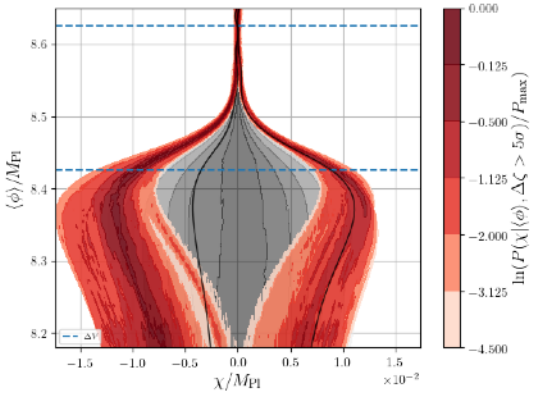
f f => c fusion of flucs into frozen-out condensate*

k /Mpc

$\Delta \ln S_G$ < 0.05
95%CL
over 10 efold CMB range

field strains n=dof+4 *cf* space strains, time strains

$S_G(\varepsilon_{AB},H_{AB})$ ~ sugra



$\varepsilon_{\phi}{}^{A}\varepsilon_{\phi}{}^{B}$ generally A,B =TXYZ $\phi,\chi,..$

inflaton strain ln $\phi(t)/\phi(ti) = \varepsilon_{\phi\phi}$

transverse field strain ln $\chi(t)/\chi(ti) = \varepsilon_{\chi\chi}$

ε_{AB}, dual $K_{AB} = d\varepsilon_{AB}/\mathcal{D}dt = H_{AB}/\mathcal{D}$

$dH_{\phi\phi}/dt + H_{\phi\phi}{}^2 + TrHxx\ H_{\phi\phi} = -\tau_{\phi\phi} + c^2\,\Delta\varepsilon_{\phi\phi} + c^2\,\nabla\varepsilon_{\phi\phi}\nabla\varepsilon_{\phi\phi}$

the (effective potential) tide $\tau_{\phi\phi}$ *is* $m^2{}_{\phi\phi}$

GRAVITY WAVES $dH^{TT}{}_{XX}/dt + TrH_{XX}\ H^{TT}{}_{XX} - c_s{}^2\,\Delta\varepsilon^{TT}{}_{XX} = -\tau_G{}^{TT}$

$dH_{XX}/dt + H_{XX}{}^2 = -\tau_{GXX} + c_s{}^2\,\Delta\varepsilon_{XX} + ..$

is the homogeneous ellipsoid acceleration equation τ_{GXX} *is the usual tide* $\nabla\nabla\Phi_N$

~ *Raychaudhuri eqn*

Lyapunov if $H_{AB} > 0$ instability, eg XYZ

damping if $H_{AB} < 0$ eg k_c

oscillation if $-i\omega_{AB} = H_{AB}$

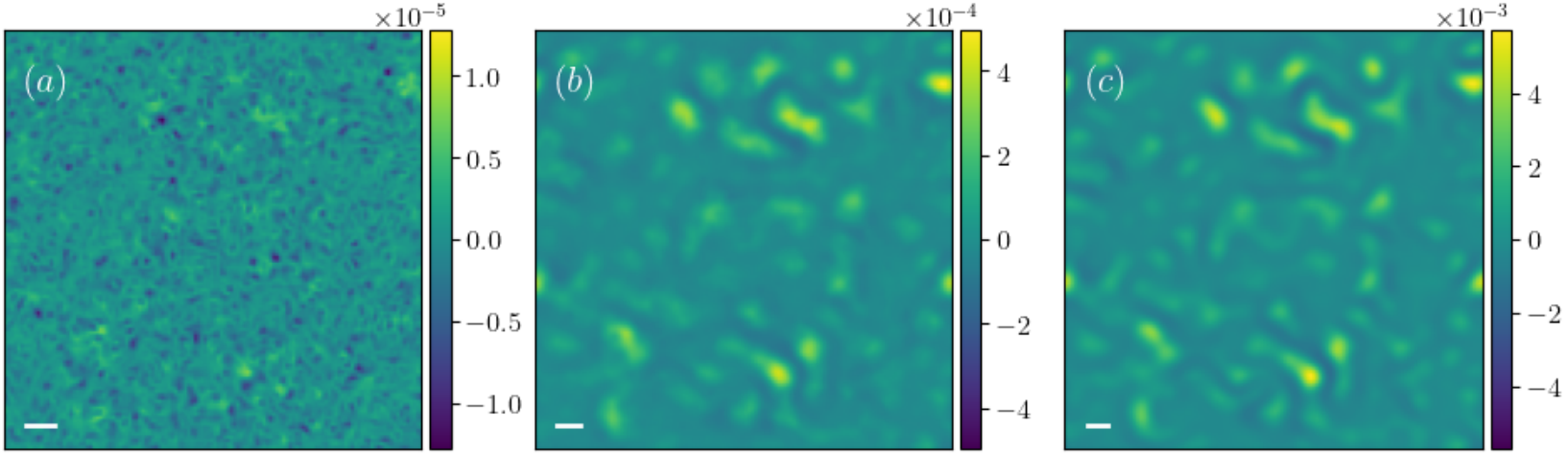
varieties of pinGs, depends upon
instability wavenumber k_p
instability strength $m^2 < 0$
duration

we chose a symmetry breaking S_{Gc} Higgs-like (+-)
also tried string-like (0,2π)

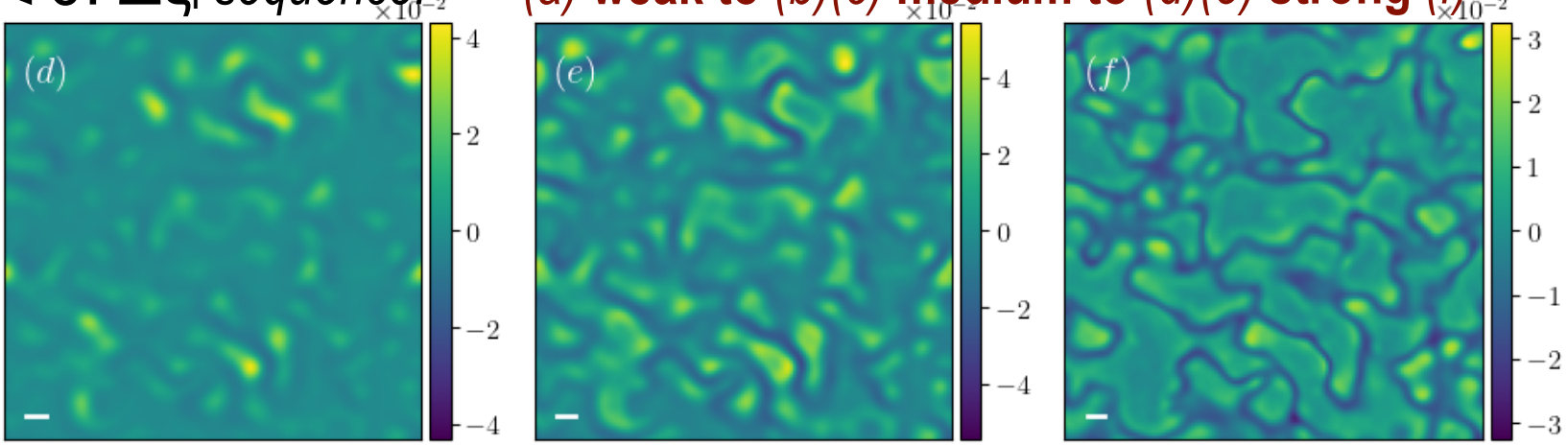
+ many different potentials

pinGponG results are generic

$\zeta_f(x \mid \Delta V+V_0$; *Bunch-Davies GRF IC*$) = \Delta\zeta_f + \zeta_f(x \mid V_0$; *BD GRF IC*$)$

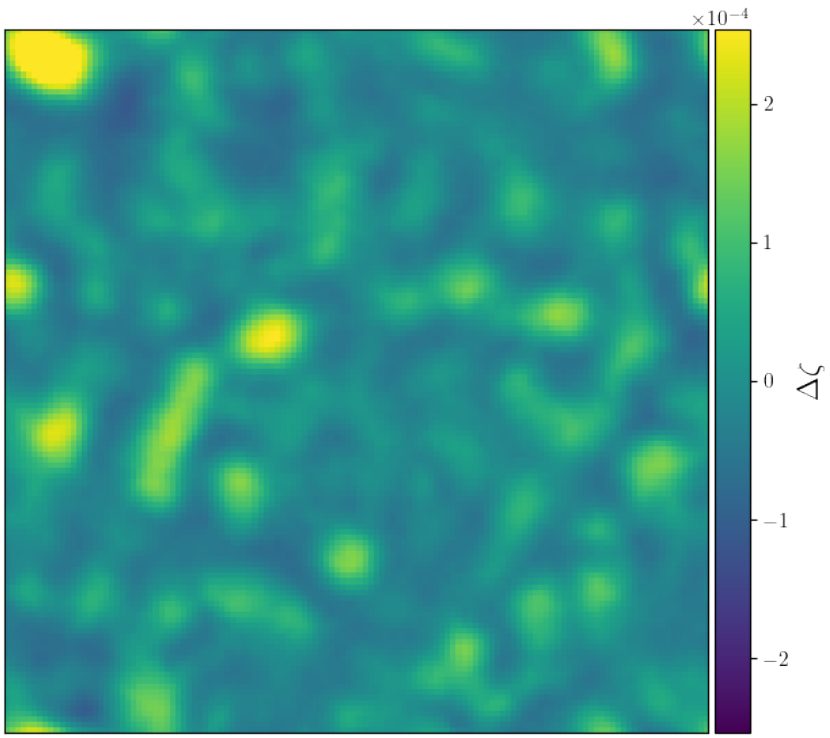


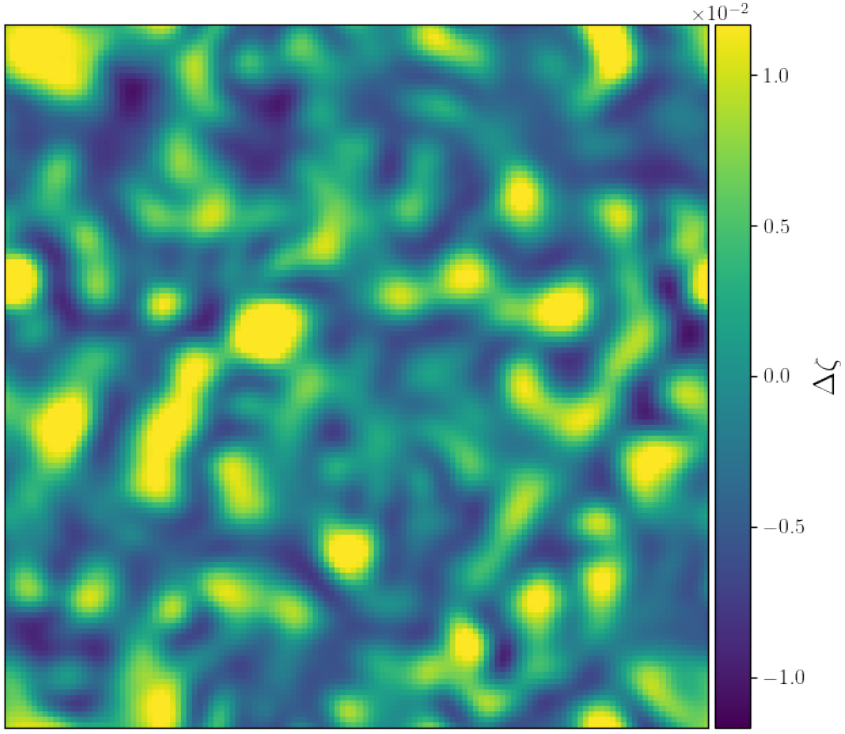
$m_{\perp\perp}^2 < 0$: $\Delta\zeta_f$ *sequence:* **<= *(a)* weak to *(b)(c)* medium to *(d)(e)* strong *(f)* =>**



domain ***wall memory*** *in* $\Delta\zeta_f$

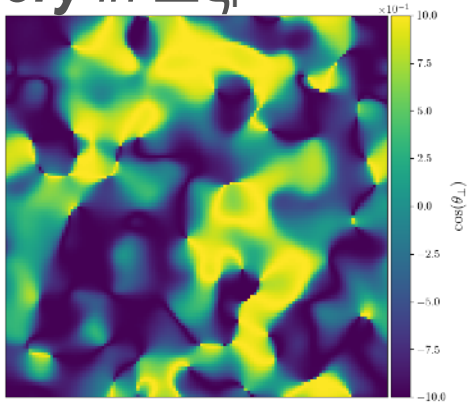
$\zeta_f(x \mid \Delta V + V_0$; *Bunch-Davies GRF IC*$) = \Delta\zeta_f + \zeta_f(x \mid V_0$; *BD GRF IC*$)$





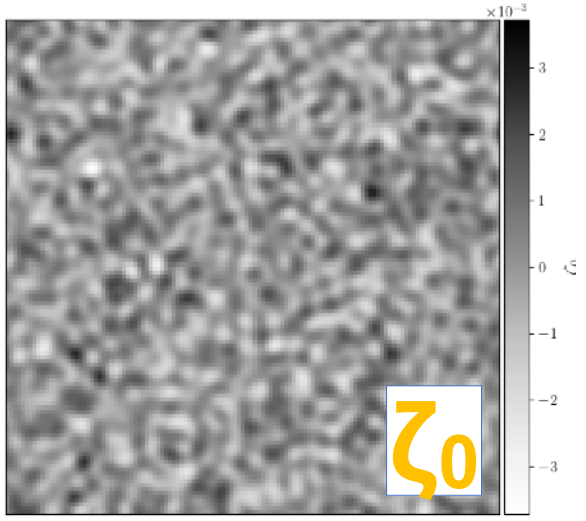
string memory *in* $\Delta\zeta_f$

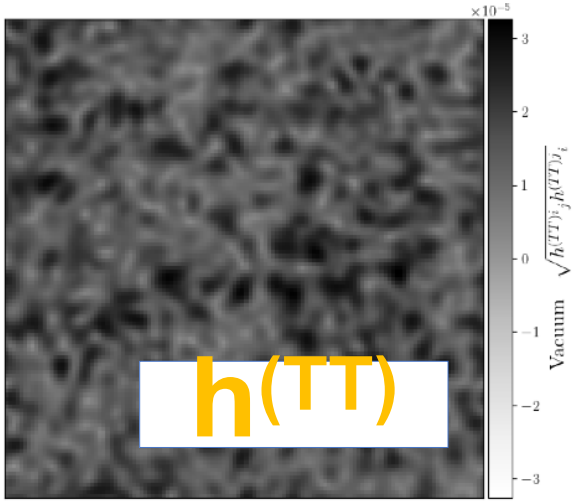
$m_{\perp\perp}^2 < 0$: $\Delta\zeta_f$ *sequence:* **medium to strong =>**



GRF from V0

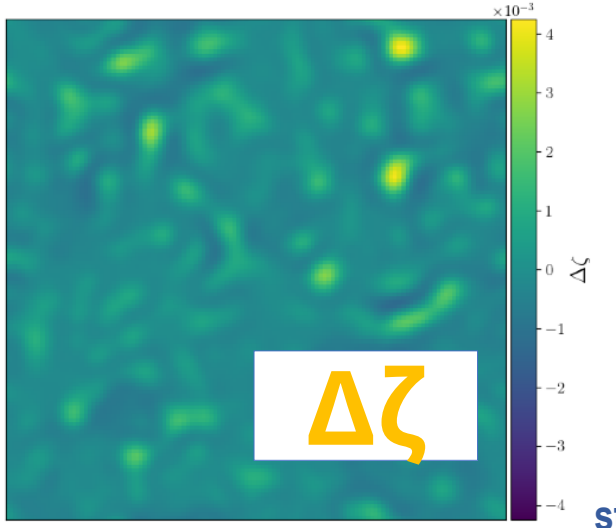
scaling √r ~4 √ε0

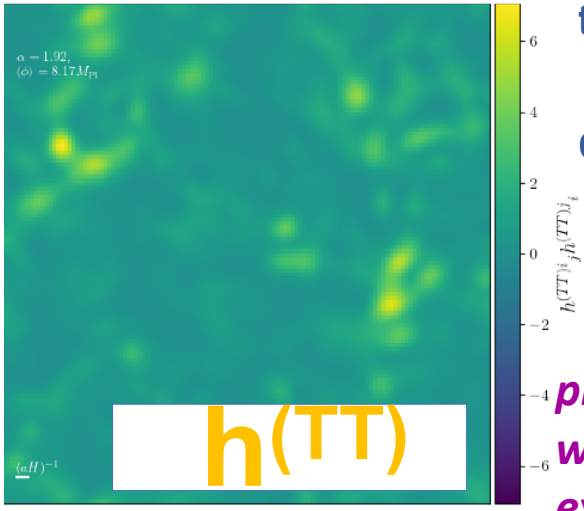




pinG from ΔV

scaling ~1/100





GRF controlled by ε0

cf

pinG controlled by instability strength

strong frozen pinG GW enter horizon then stream to a stochastic background, "tunable" GW frequency < 30 GHz, down to ~ 10^{-20} Hz

pinGponGs less radical than PBHs, which are super-strain ponGs, extreme tail modifications of Veff?!

PBH target is Δζ > .01 to .1

Δζ>1 is (semi-) eternal inflation

pinGponG GW correlated with pinGponG ζ instability TT amplifies anisotropic stress source for GW. 2 stages, during inflation propagation from Π^{TT}

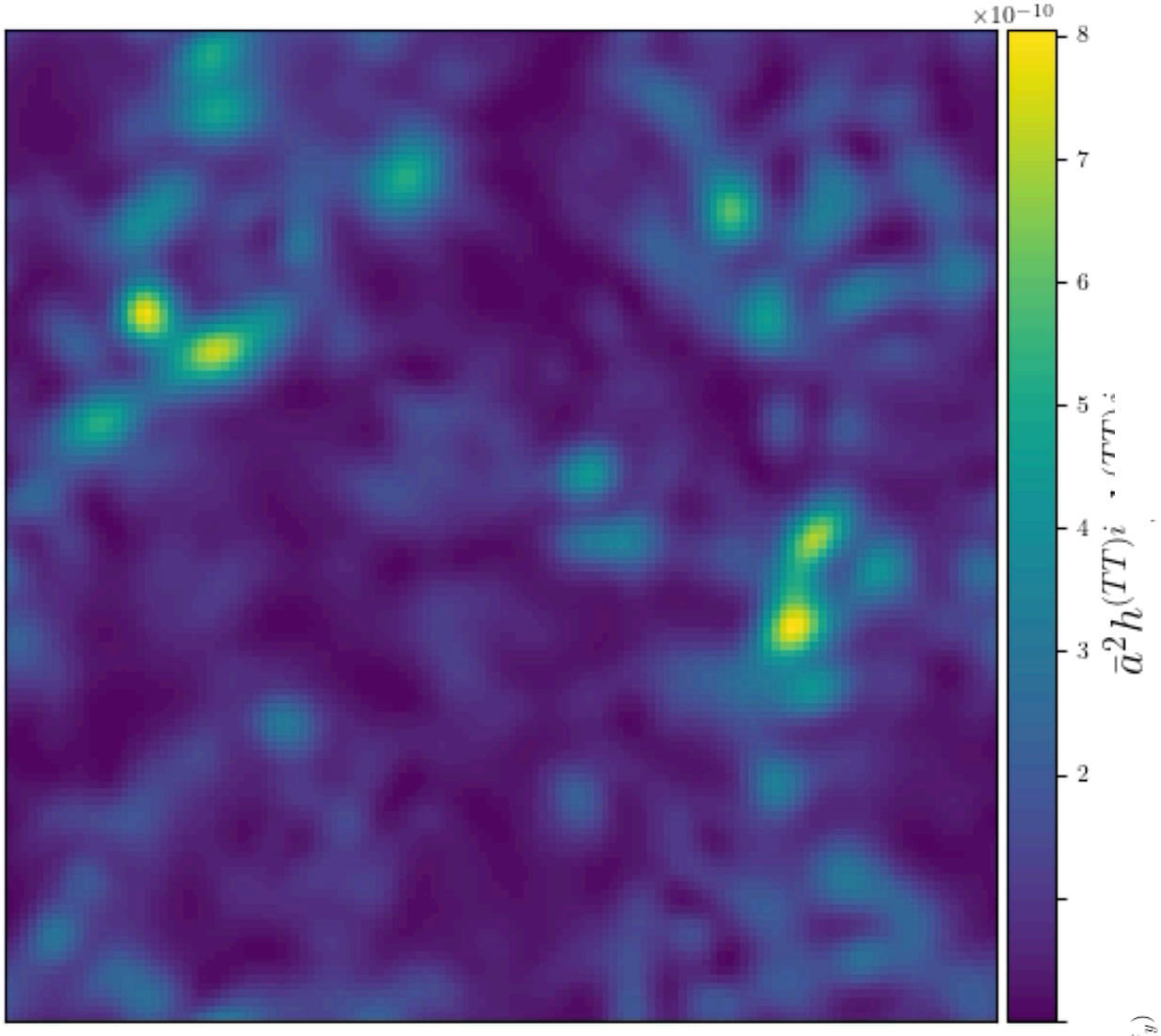
late times further propagation

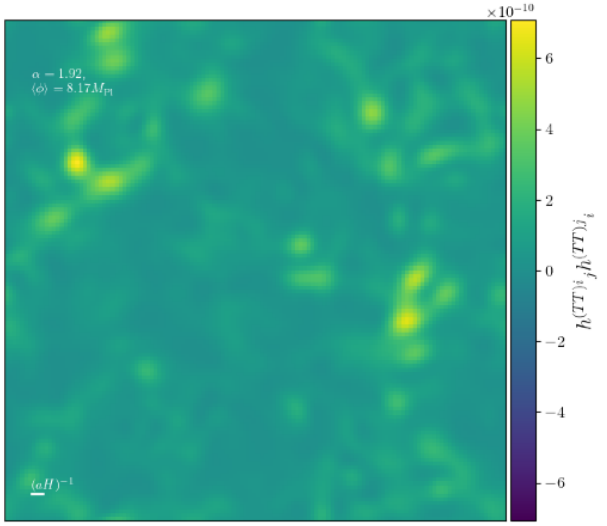
=> overlap of the GW sources

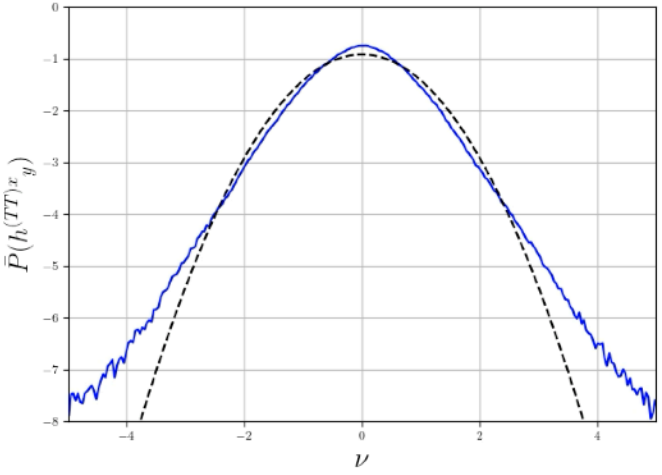
~ stochastic background

complete reconstruction of Π^{TT} & h^{TT} from ζ

frozen h^{TT} re-enter horizon => flow to GW ping overlap, stochastic GW - enough overlap tends to Gaussian







frozen h^{TT} re-enter horizon
flow to GW ping overlap,
stochastic GW
enough overlap tends to Gaussian

finally after 15 years, 5 papers in next few months, 0a,0b (90s + recent) bond on general stochastic morrison thesis work with bond+braden

paper 0: bond, stochastic framework, emergence of Signal (c) from Noise (f), coherent from incoherent, ph condensate defines coherence. kc(xc), boundary between kL and ks aka kf

paper 1: morrison, bond, braden 24 pinGs methods and relation to stochastic inflation

paper 2: morrison, bond, braden 24 pinGs as source population

$\zeta(x,t) \sim \int \Delta\zeta nG\text{-}Prominences(x\text{-}x_c)\, dN_e(x_c R_c)$ + Gaussian *random ζ-flucs*

paper 3: morrison, bond, braden 24 pinGs as functions of strained transverse gaussian field

$\zeta(x,t) \sim \sum_p \Delta\zeta nG(\chi_p(x,\alpha_e))$ + Gaussian *random ζ-flucs*, $\quad \chi_p(x,\alpha_e)$= Gaussian *random*

paper 4: morrison, bond, braden 24 nonGaussian Gravity Waves from transverse traceless pinGs

clustered **pinGponG** *sources are* **generic**

{$\mathbf{k_p}$} could be anywhere & everywhere

at low L, relation to anomalies? GW: correlated QU *aka* BE

stochasticity depends on degree of wave propagation inside horizon

can be strong in the 50 e-folds below the CMB-LSS regime,

from k~ 1/Mpc down to k~ 1/cm,

e.g., modifying galaxy formation intermittently, seeds for PBH, VMBH, SMBH.

JWST issues, weak constraint from first stars