CIFAR CANADIAN INSTITUTE FOR ADVANCED RESEARCH

CITA ICAT Canadian Institute for Theoretical Astrophysics / L'institut canadien d'astrophysique theoriq

Dick Bond

CITA = **Cosmic Information Theory & Analysis**

*from **SuperWeb simplicity** to **complex Intermittency** in the Cosmic Web*

Studying the Cosmic Tango *Universe=System+Res, =Data+Theory*

CIFAR Cosmology & Gravity Program: >1985, Bond Director 2002-17 => CIFAR Gravity & the Extreme Universe Program Sr Fellow 17-22 CITA: 6+ faculty, ~20 PDFs & Sr RAs + ~20 grad students; Bond: projects 5 grad students, 2 SrRAs, 2 (++) PDFs, 4SUGs+2VMSc +..

Cosmic standard model SMc = xCDM, x=dark energy+tilt: what is U made of?

Planck13-15-18 *CMB, CvB, GW, dark matter, baryons, dark energy/modGravity, CIB:*

$\rho_{dm}/\rho_b = 5.37$ $\rho_{de}/\rho_{dm} = 2.60$ $\Omega_m = 0.315 \pm .007$, $\Omega_\Lambda = 0.685 \pm .007$ GW/scalar <.07 .. =>

BSMc Beyond the SMc *eg* ***cDE*** $\Omega_\Lambda(t,x)$, neutrinos, inflation anomalies, ***fDM=beCDM***

How Structure in the Universe Arose?: *fluctuation generation in curvature from an early **inflaton: reconstruct** ln **a(x,t)** ~ **phonons**, isocurvature, **r** Gravity Waves*

HEAT *(coherence + quantum noise => incoherence via entropy generation) via nonlinear lattice simulations of multiple scalar fields at the end of inflation* <=>dynamical systems **KS**

=> CMB/LSS Anomalies from EarlyU intermittent non-Gaussianity cf. perturbative non-Gaussianity, correlated & uncorrelated => **CITA in CMB + LSS large surveys**

CMB*ology* **precision cosmic parameters** ***Planck* 2013-15-18 intensity + polarization** *+ ACTpol + BK +SPT* **=>** *Spider, Advanced ACTpol CCATp => Simons Obs => CMB Stage 4, …* **&**

LSS*ology* ***CHIME, COMAP, Euclid … & cross correlations: CMBxLSS = webXweb***

morphs *into the nonlinear* ***Cosmic Web:*** ***Websky*** **Mock sims:** ***clusters, filaments, voids; galaxies tool Mass-peak-patches, N-body, gas: Lens, tSZ, kSZ, CIB, CO, HI (21cm, Hα, Lyα) optical***

LIM/LAM Line Intensity Mapping ***cosmic response functions*** ***dynamical, coupled? dark energy***

the true quadratic ζ-Websky of the ζ-scape

Planck 2018 inflation: TTTEEE lowL Epol + CMBlens + BK14 BB + *BAO*

Bond +Zhiqi Huang +Andrei Frolov

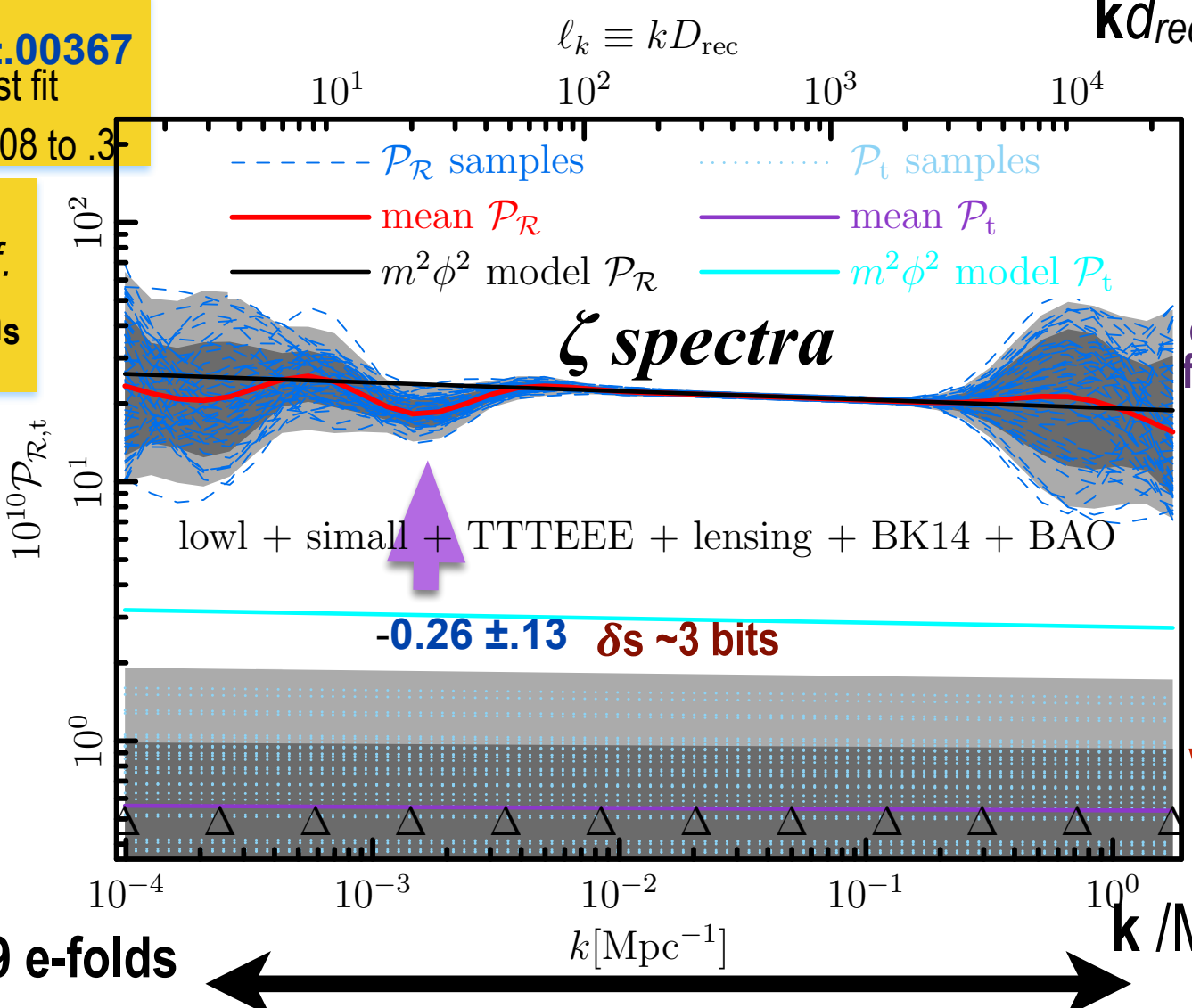
CMB TT power L~ 20-30 dip => ζ-Spectrum k-dip; *includes CMB lensing, parameter marginalization*

uniform n_s=0.9669±.00367
P18+BK14 LSS best fit
superb 12-knot fit k~ .008 to .3

r<.084 95%CL *cf.*
r<0.068 uniform n_s

stochastic inflation
$|\phi_{cg}\,;\,\phi_{fg}\rangle$
coherent state picture
of coarse-grain
condensate
+ *fine-grain*
bugoliubov fluctuations
QM-correct

9 e-folds



kd_{rec} ≳L

=> lots of room for large ζ =>

=> V(ϕ)

k /Mpc

GW** from **CMB-T/S=r** via **Spider, AdvACT, SO, S4**, LiteBird **hopes realized** only **if ISM cooperates!

dust maps in intensity and polarization are manifestly non-Gaussian, not statistically isotropic, not derived from a statistically homogeneous random field. yikes.

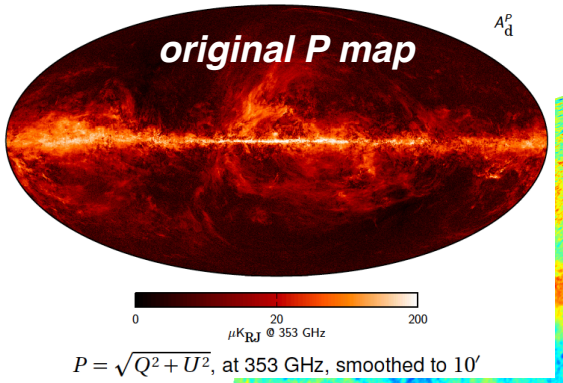
"CMB/LSS" ideas on complex dust, synch ISM data, Planck. goal = simplified compression of data

e.g. anisotropic random tensor fields of transformed fields:

s(P,X, s2,s1) =- *log*{n(P,X, s2,s1)}+1, *n(P,X, s2,s1) = 2X2 distribution fn matrix (Wigner)*

=> ln I and p =P/I, e=E/I, b=B/I, q=Q/I, u=U/I, with some large-p modifications

maps look more Gaussian, but still not => Gaussianized variables .. +anisotropy by stacking



=> ensemble of simulated b maps via randomized b-fluctuations, with modes L=1 to 4 constrained (+ other constraints TBD)