



Dick Bond

CITA = Cosmic Information Theory & Analysis

from *SuperWeb simplicity to complex Intermittency in the Cosmic Web*
IT from BIT, from BITs in IT, Studying the Cosmic Tango
Universe=System+Res, =Data+Theory en-TANGO-ment

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 + ~15 grad students; Bond: projects 4 grad students, 3 SrRAs, 1 (++) PDFs, 3SUGs

Cosmic standard model SMC = Λ CDM, Λ =dark energy+tilt: what is U made of?
Planck15-17 CMB, C_vB, GW, dark matter, baryons, dark energy/modGravity, CIB:

$$\rho_{\text{dm}}/\rho_{\text{b}}=5.43 \quad \rho_{\text{de}}/\rho_{\text{dm}}=2.53 \quad \Omega_{\text{m}}=0.32 \pm 0.009, \quad \Omega_{\Lambda}=0.68 \pm 0.009 \Rightarrow$$

BSMC Beyond the SMC eg $\Omega_{\Lambda}(t,x)$, neutrino properties, inflation anomalies

How Structure in the Universe Arose?: fluctuation generation in curvature from an early inflaton: POWER $\ln a \sim$ phonons, isoc, GW(k): isocurvature, Gravity Wave; (coherence + quantum noise => incoherence HEAT via entropy/information generation) via nonlinear lattice simulations of multiple scalar fields at the end of inflation & "ballistics" => CMB/LSS Anomalies from EarlyU intermittent non-Gaussianity cf. perturbative non-Gaussianity, correlated & uncorrelated => CITA in CMB + LSS large surveys

CMBology precision cosmic parameters **Planck 2013-15-17** intensity + polarization + ACTpol + BKP + SPT => Spider, Advanced ACTpol CCATp => Simons Obs => CMB Stage 4, ... & **LSSology** CHIME, COMAP, Euclid ... & cross correlations: **CMBxLSS = webXweb morphs** into the nonlinear **Cosmic Web: clusters SZ, filaments, voids; galaxies Mass-peak-patches, N-body, gas to Mock Heaven: Lens, tSZ, kSZ, CIB, CO, HI (21cm, H α , Ly α) optical**

What is the fate of the U: (dynamical, coupled?) dark energy driving late inflation

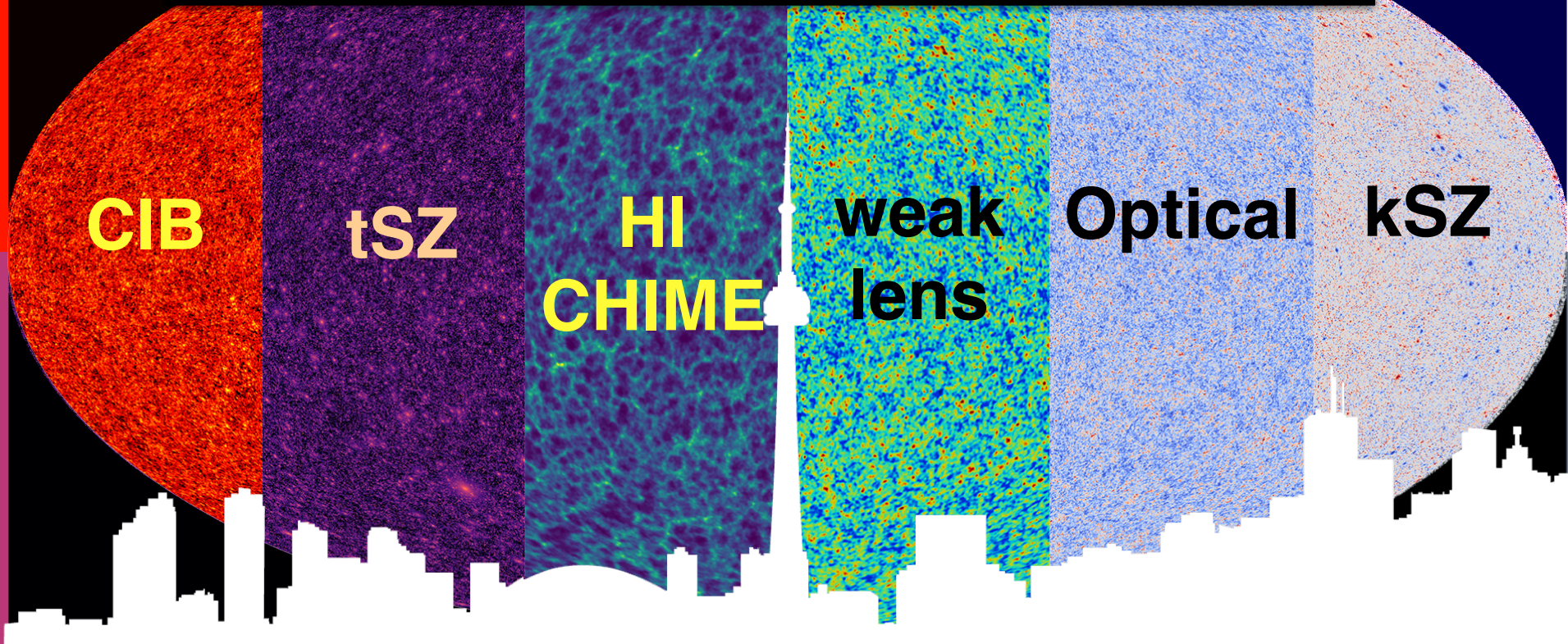
Mocking Heaven's Web with *PeakPatches++*

Dick Bond @ Physics Jamboree 17

Planck, AdvACT, SO, CMB-S4, CCATp, EUCLID, LSST, CHIME, HIRAX, COMAP, ...SKA
*Line Intensity Mapping and Line Absorption Mapping **fLIMfLAM***

CITA mini-industry: Marcelo Alvarez, Dick Bond, George Stein & Battaglia, Codis, van Engelen & FIRE: Lakhiani + Murray + Hopkins + Berger & Connor Bevington, Bruno Régaldo-Saint Blancard, Ronan Kerr, Louis Pham

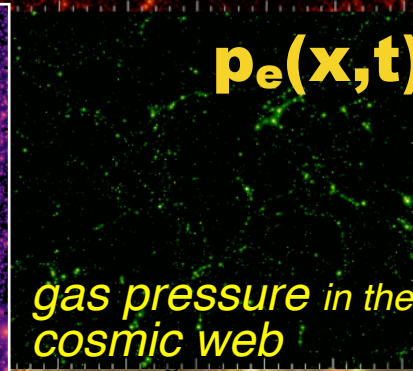
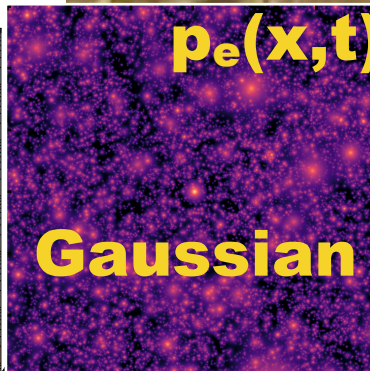
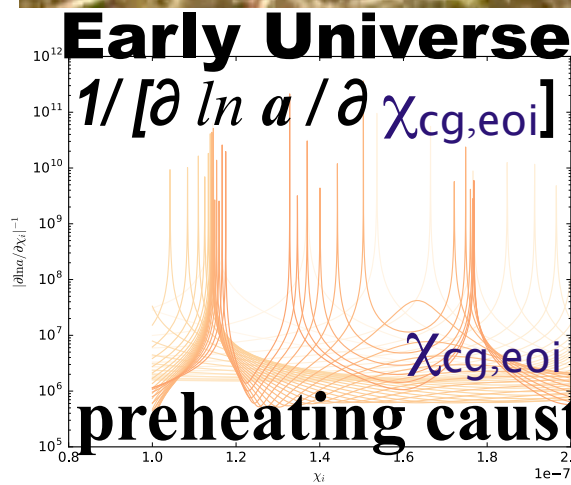
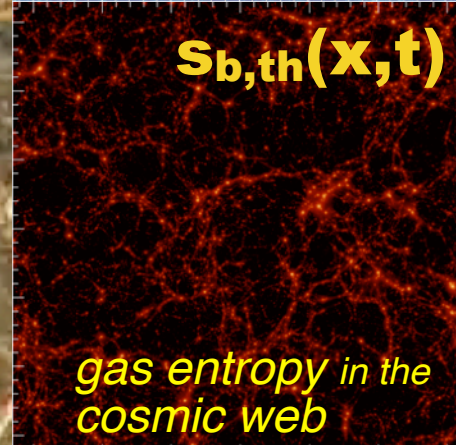
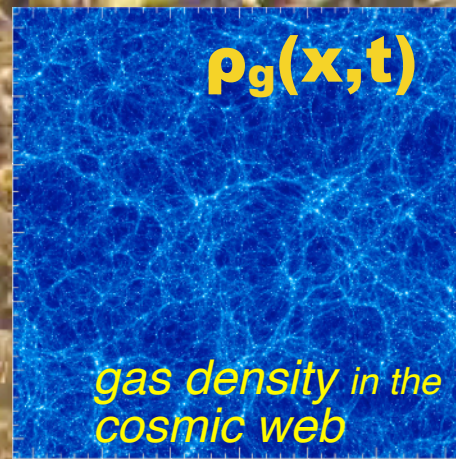
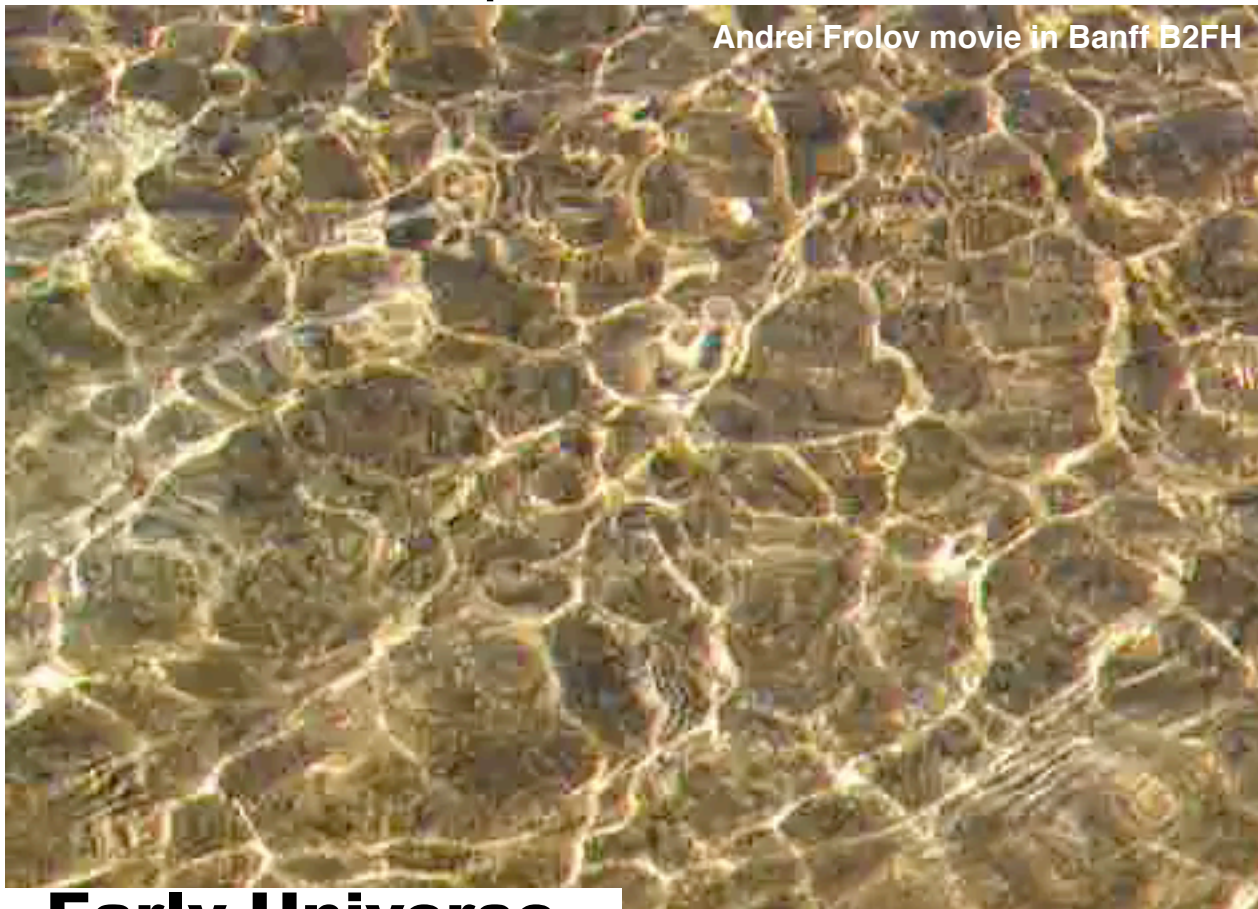
*need **End to End** mocks: BSM, nonG, DE/modG, Mnu, ...*
*need **all signals** to be correlated, 1, 2, 3, .. Npt*
*need **speed** to build ensembles & explore BSM*



*Planck 2015 XII: Full Focal Plane Sims: FFP8 ensemble of 10K **EndtoEnd** mission realizations in 1M maps. instrument noise + CMB + PSkyModel + .. (25M NERSC CPU hrs)*

caustics are ubiquitous: LSS/cosmic web & preheating

Andrei Frolov movie in Banff B2FH



preheating caustics