CITA = **Cosmic Information Theory & Analysis**
*from **SuperWeb simplicity** to **complex Intermittency** in the Cosmic Web*
***Studying the Cosmic Tango*** *Universe=System+Res, =Data+Theory*

**Dick Bond**

*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 4 grad students, 3 SrRAs, 2 (++) PDFs, 3SUGs+1VMSc +..*

***Cosmic standard model SMc =*** *x*CDM, *x*=dark energy+*tilt:* what is U made of?
Planck13-15-17 *CMB, CvB, GW, dark matter, baryons, dark energy/modGravity, CIB:*
$\rho_{dm}/\rho_b=5.43$ $\rho_{de}/\rho_{dm}=2.53$ $\Omega_m=0.32 \pm.009$, $\Omega_\Lambda=0.68 \pm.009$ =>

***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: 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

=> *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* 2013-15-17 intensity + polarization + *ACTpol* + BKP +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:** **Mocking Heaven** *clusters* SZ, *filaments, voids; galaxies Mass-peak-patches, N-body, gas: Lens, tSZ, kSZ, CIB,CO, HI (21cm,Hα,Lyα) optical*

**Line Intensity Mapping** **constrained patch stacks** fate *(dynamical, coupled?)* *dark energy*

**Topography** of the **CMB-web, ζ-web, IQU/ E B, ISM-web, y-web, LIM/LAM web**

*oriented/symmetry-broken* **stacking** on field points peaks saddles *(cols, passes)*

ACTPol *stack*
**<T,E,B|T-field>**

*B+Frolov+Huang 17*

**<Qr |oriented I-pk>**

ζ
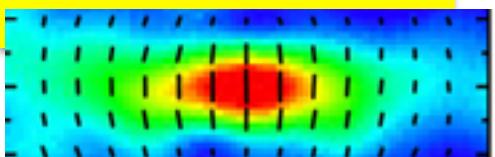
Planck 353 GHz stacked dust
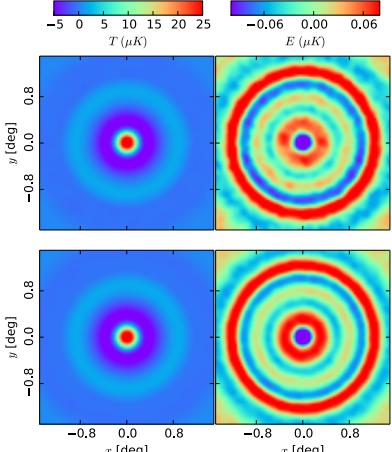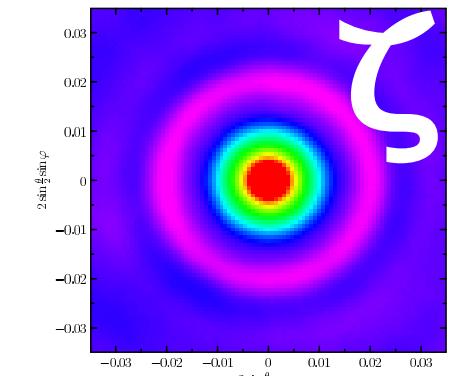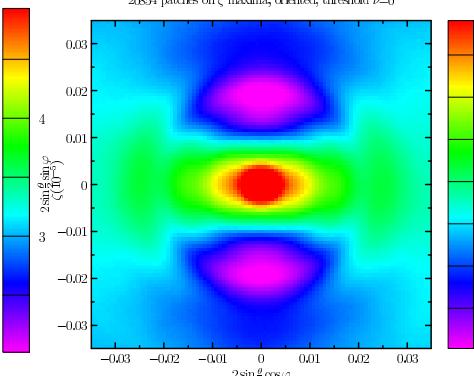
**earlyU SuperWeb map** Planck2015 XVII
**stacked ζ-map | ζ-pk TQU>** BFH17

**I-saddle stack**
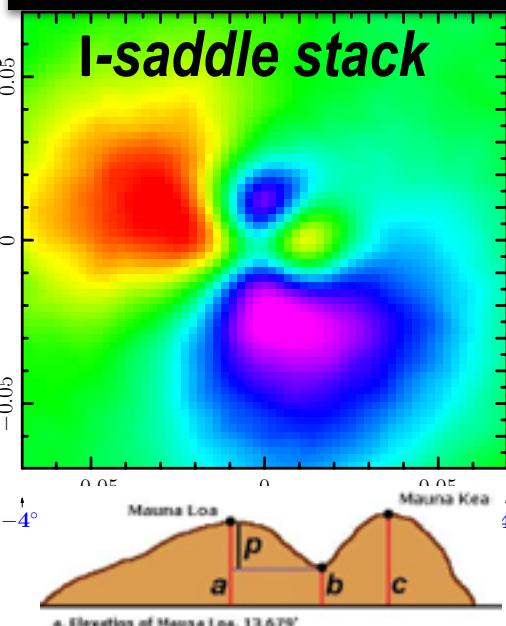
N = 386 clusters; z > 0.70

*tSZ on Clusters*
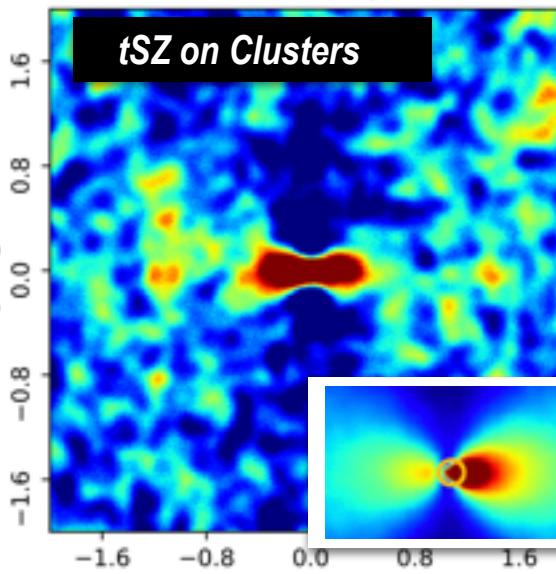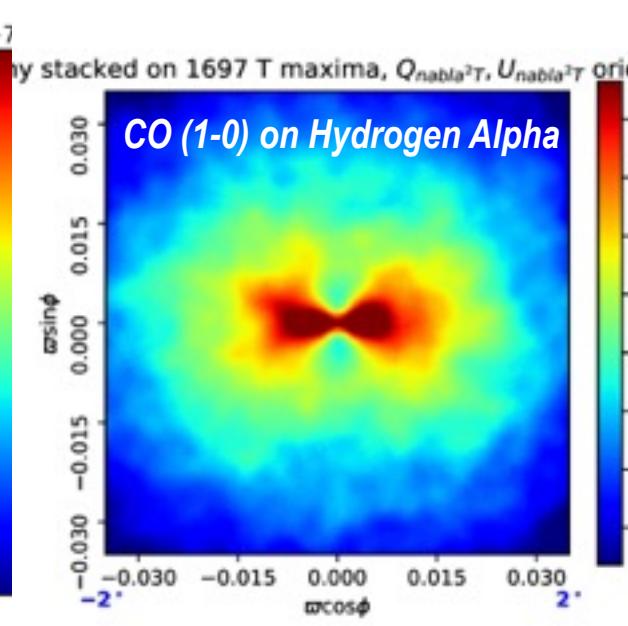
*CO (1-0) on Hydrogen Alpha*
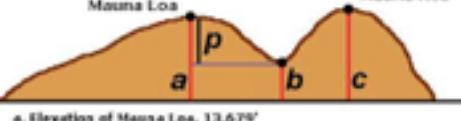
# caustics are ubiquitous: **LSS/cosmic web & preheating**



Andrei Frolov movie in Banff B2FH

$\zeta_{dm}$ $^{cf.}\int KS_{dm}$

**Early Universe**

$1/[\partial \ln a / \partial \chi_{cg,eoi}]$

$\zeta$

$\chi_{cg,eoi}$

**preheating caustics**
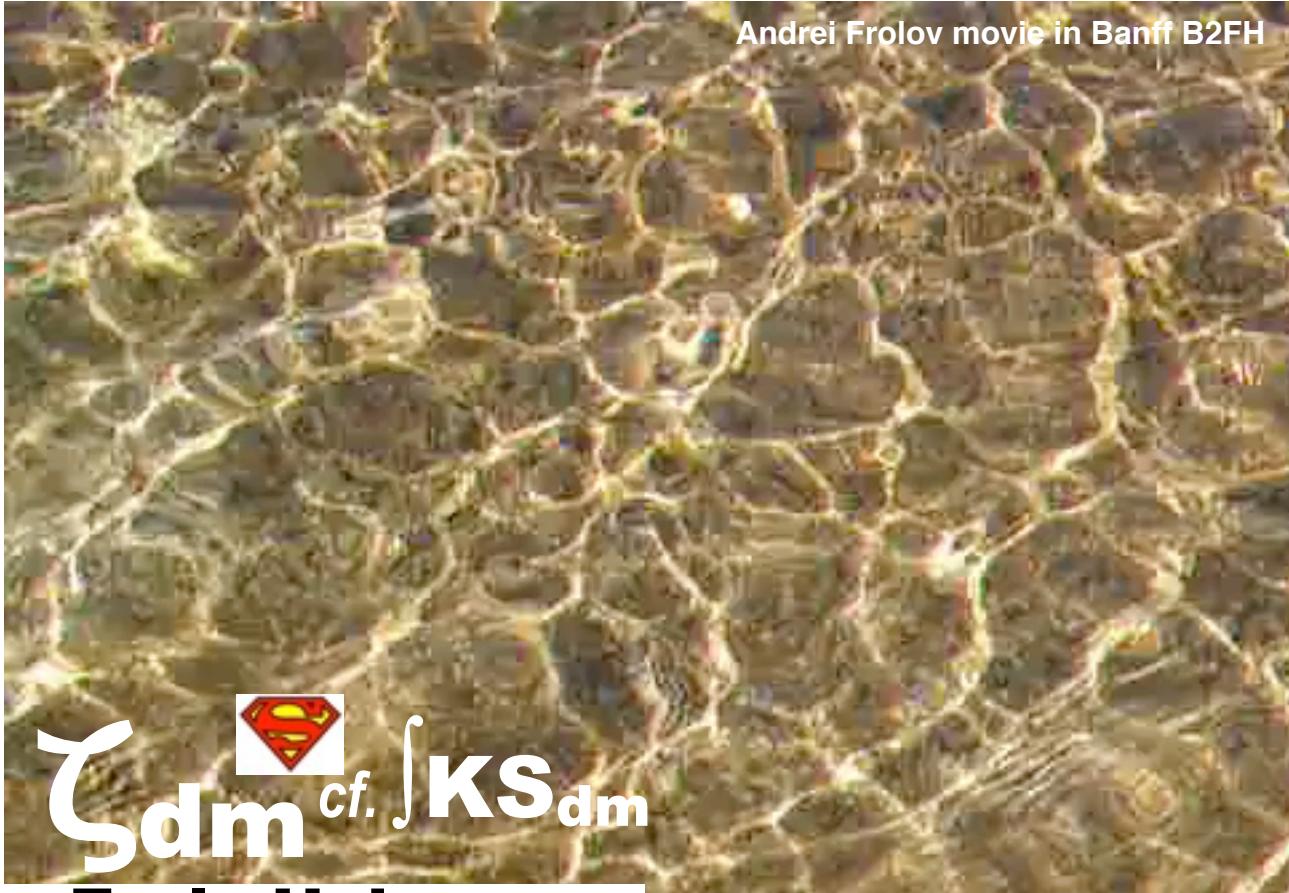
$\rho_g(x,t)$

*gas density in the cosmic web*

$s_{b,th}(x,t)$

*gas entropy in the cosmic web*

$p_e(x,t)$ tSZ

Gaussian

or
G+non-G

$p_e(x,t)$

*gas pressure in the cosmic web*
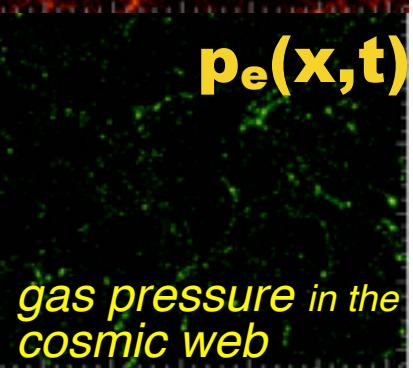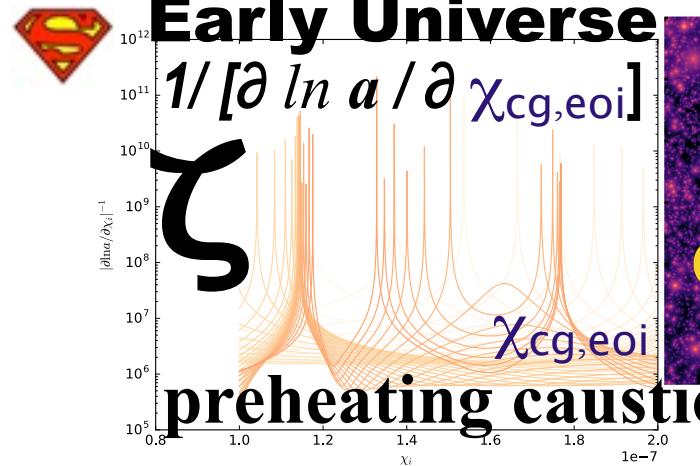
# Mocking Heaven *with PeakPatches*++

**Dick Bond @ CITA 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: Lakhlani + 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**

**CIB** **tSZ** **HI CHIME** **weak lens** **Optical** **kSZ**
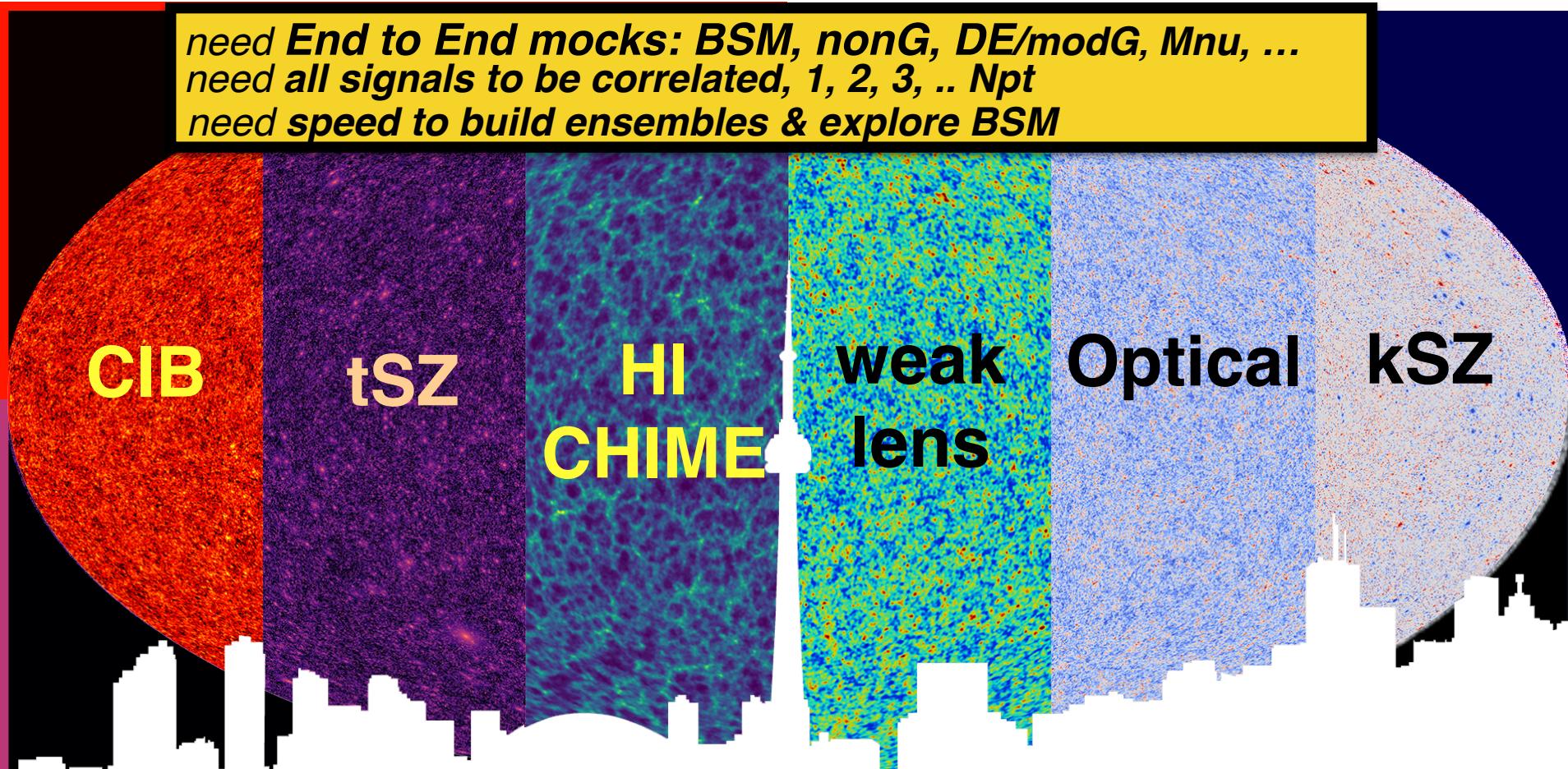
*Planck 2015 XII: Full Focal Plane Sims: FFP8 ensemble of 10K **End**to**End** mission realizations in 1M maps. instrument noise + CMB + PSkyModel + .. (25M NERSC CPU hrs)*