

CITA = Cosmic Information Theory & Analysis: IT from BIT, from BITs in IT, *Studying the Cosmic Tango*

Universe=System+Res, =Data+Theory **en-TANGO-ment**

Dick Bond

CIFAR Cosmology & Gravity Program: >1985, 22 fellows & scholars (5@UofT), 19
 associates + 6 Advisory Board members; CITA: 6+1 faculty, ~26 PDFs & Sr RAs +
 ~15 grad students; Bond: projects with 3-1 grad students, 5-1 SrRAs, 2 (++) PDFs



Cosmic history: what is U made of? $\Rightarrow \rho_{dm}/\rho_b=5.1$

$\Rightarrow \rho_m/\rho_{de} = .30$ & $\Omega_m=0.268 \pm .012$, $\Omega_\Lambda=0.736 \pm .012$

**How Structure in the Universe Arose?: fluctuation generation in curvature
 from an early inflaton: isocurvature, Gravity Wave, non-Gaussianity signatures**

(coherence + quantum noise \Rightarrow incoherence via entropy/information generation)

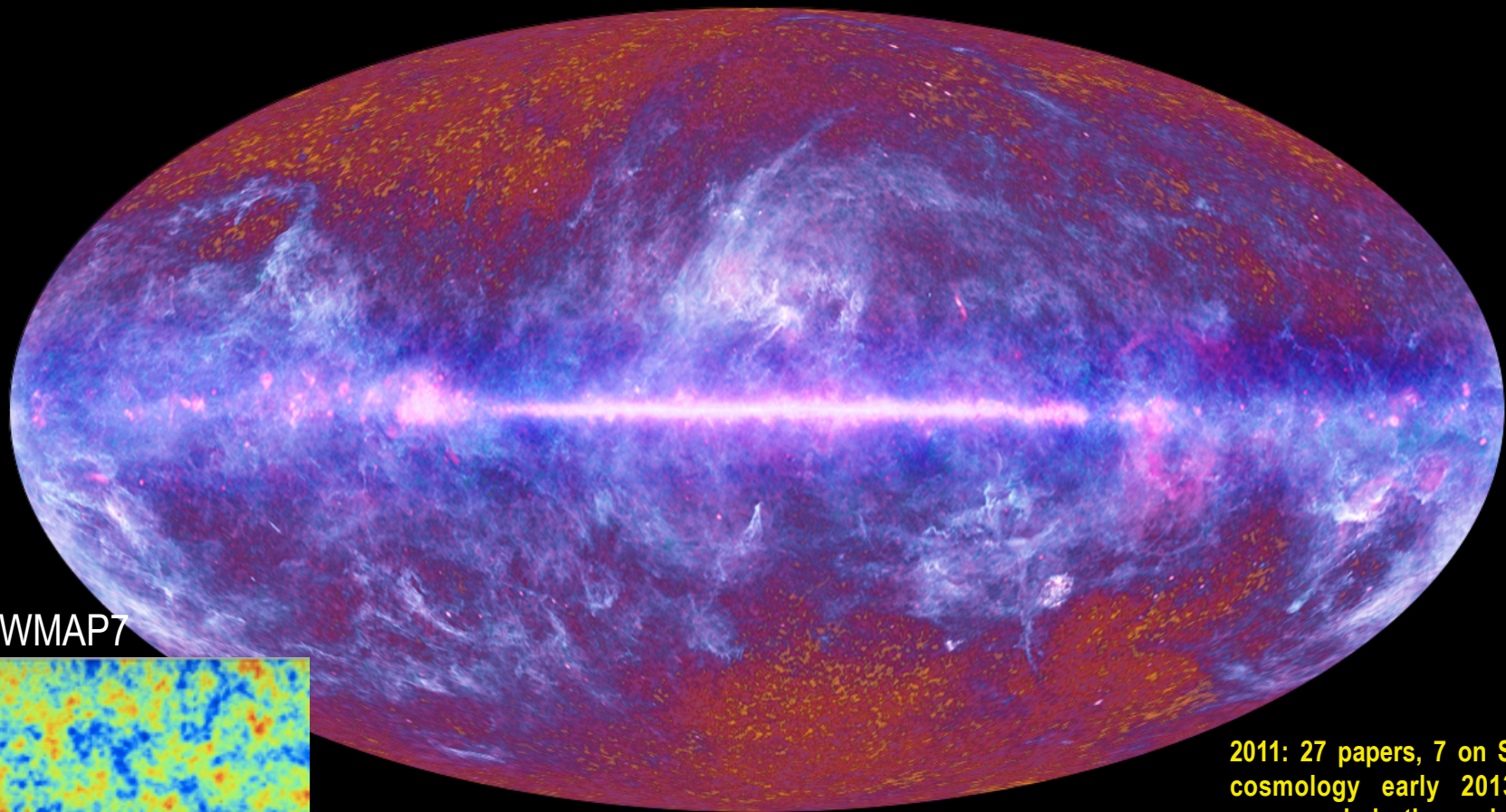
morphs into the nonlinear Cosmic Web: clusters, filaments, voids; galaxies (SZ)

What is the fate of the U: dark energy properties driving late inflation

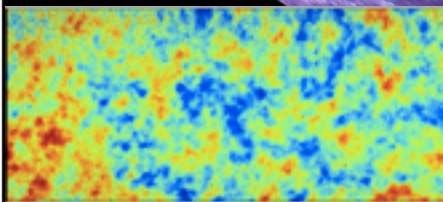
**CMBology & Λ CDM, Λ =dark energy+tilt: the cosmic standard model
 status@Mar12: uses WMAP7+ACT (SPT), past: Boom, CBI, Acbar,.. (QuAD, ...)**

**Planck cosmology Jan13 ultra-precision on cosmic parameters 2011(27p), Feb12
 ACTpol, ABS, Spider, Quiet-2, .. ALMA, CARMA, Mustang2 on GBT, CCAT**

Prob (cosmic parameters & trajectories | CMB+LSS data, theory-framework)



ACT+WMAP7



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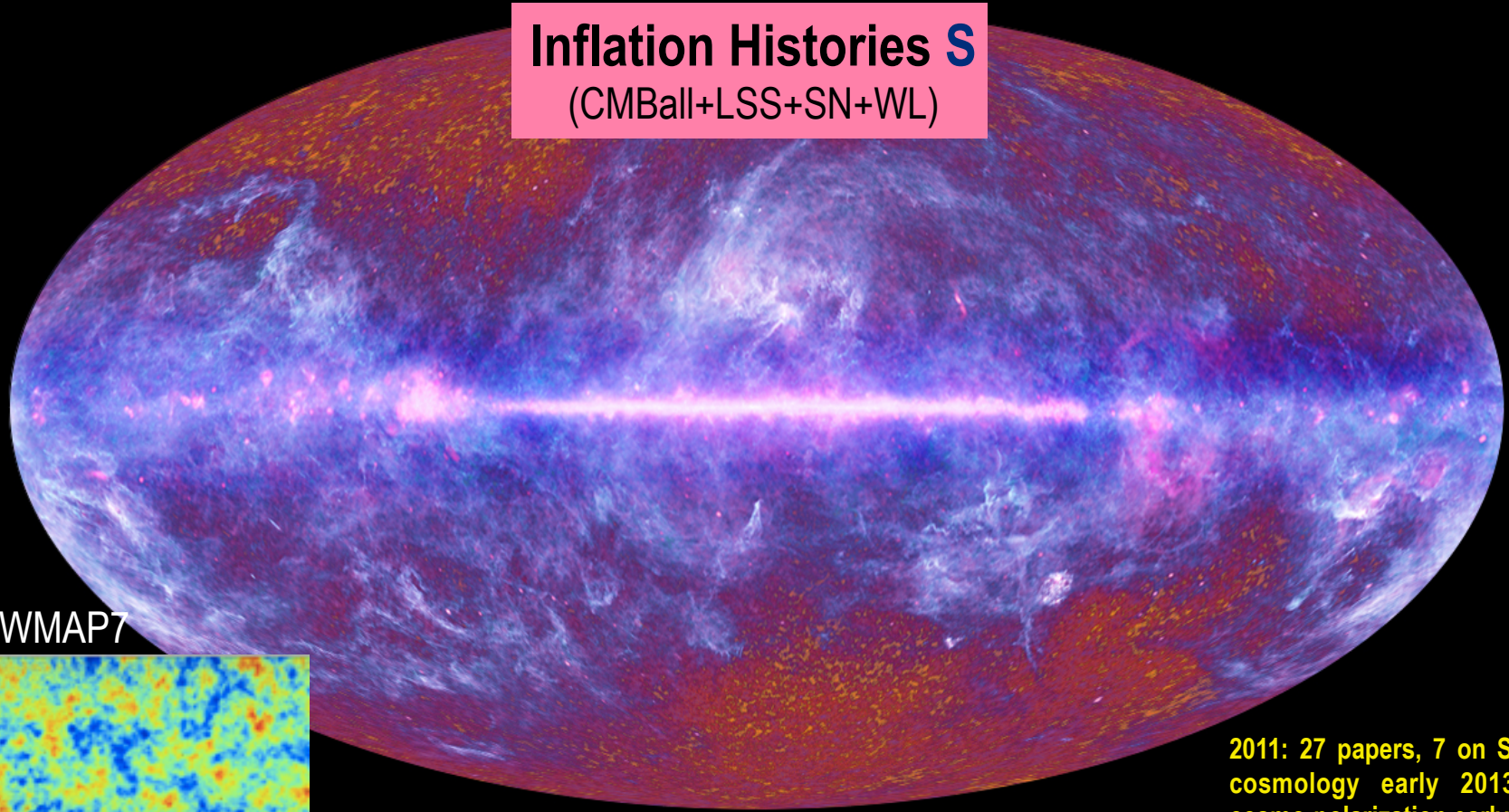
(c) ESA, HFI and LFI consortia, July 2010

Beyond the standard model: tilted Λ CDM + x

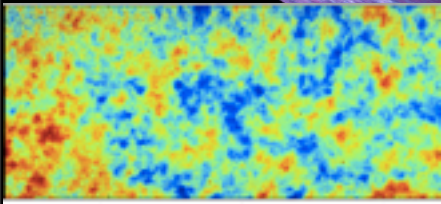
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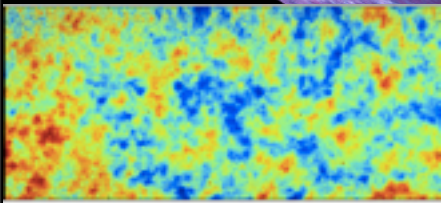
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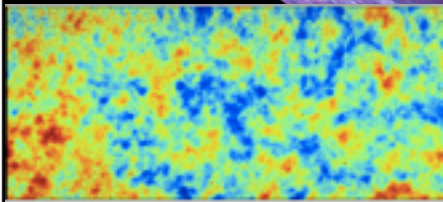
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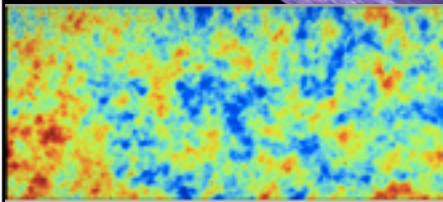
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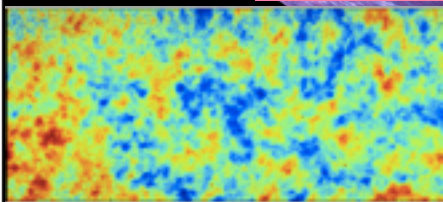
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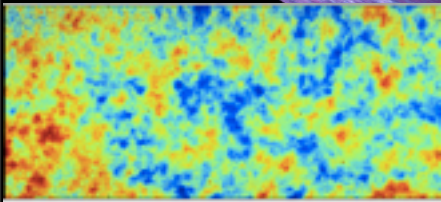
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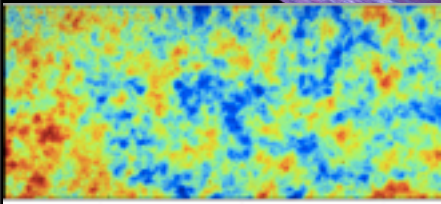
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Dark Energy Histories S

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Foregrounds, Sources

S Component Separation
 7 veils(v)+CMB, Planck+

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Planck satellite, CMB all-sky, 9 frequencies, & polarization: ESA+NASA+CSA, B since 93, CSA since 02, launch may09, 4 full skies done, 5 in all, great data B+ Miville-Deschenes (SrRA), Nolta (SrRA), Netterfield (Prof), Marleau (DAA), Chluba (SrRA), Martin (Prof) + Contaldi, MacTavish, Crill, Dore (ex-CITAZens)+hundreds more - Europe+US P11 (ISM,SZ,CIB,sources,...), P12, cosmic: P13, P14
WMAP1.3.5.7 all sky 5 frequencies Nolta (SrRA). stopped taking data Aug10 **WMAP9** winter12

s Early Universe non-Gaussianity: B+ Braden (GS), Huang (GS=>PDF), Frolov ex-CITAZen

probing CMB non-Gaussianity: B+ Frolov, Nolta, Huang. Cold/Hot Spots; quadratic nonlinearities

CMB@ hi res: CBI2 finished data in 09 - new cluster results, B+ Sievers (SrRA=>Princeton)

Atacama Cosmology Telescope@very hires: B+ Hajian (PDF), Nolta, Sievers, Switzer (SrRA), Battaglia (GS), Hincks (SJ) finished taking data Jan11 => **ACTpol Fall11** neutrino masses, inflation, cluster physics, dark energy properties, **lens ACTpol+Planck +... very powerful!**

s Clusters & Cosmic Web Gasdynamical Simulations, & the Intracluster Radio Web:

B+ Nick Battaglia (GS, PhD Aug11=>CMU PDF), Pfrommer (ex-SrRA), Sievers (SrRA=>Princeton) ACT,Planck, CBI (SPT,...,SKA)

ABS; Quiet2; Chile-based **Spider** balloon-borne **CMB expts targeting primordial gravitons via CMB pol**
B+ Nolta, Sievers B+ Sievers B+ Netterfield, Farhang (GS) +,Barth-team, ++ **GW/scalar $r \approx 0.01 V / (10^{16} \text{Gev})^4$**

Probing Recombination epoch with the CMB: B+ Chluba (SrRA), Farhang

s GW & Acceleration Trajectories: B+ Huang, Vaudrevange, Contaldi; B+ Farhang, Dore, Netterfield

s Post-Inflation Preheating: B+ Braden (GS). **How Entropy Arose in U via a Shock-in-Time**

s Late-time Inflaton Trajectories & Dark Energy cf. CMB,LSS,SN now/future: B+ Huang

s Magnetohydrodynamical Turbulence Simulations & Polarized Dust, B+ Farhang, Miville-Deschenes, +..., ..

CHIME, neutral hydrogen via redshifted 21 cm Baryon Acoustic Oscillations & Dark Energy: Pen (Prof)++ B+ Canadian Consortium: site DRAO in BC