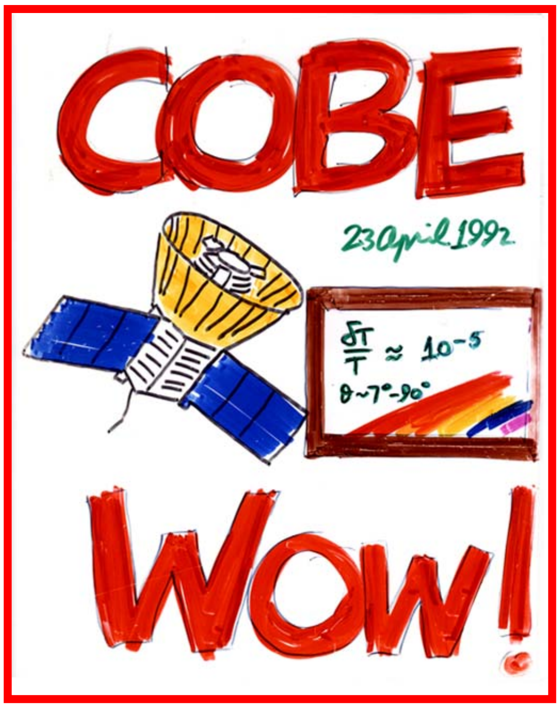
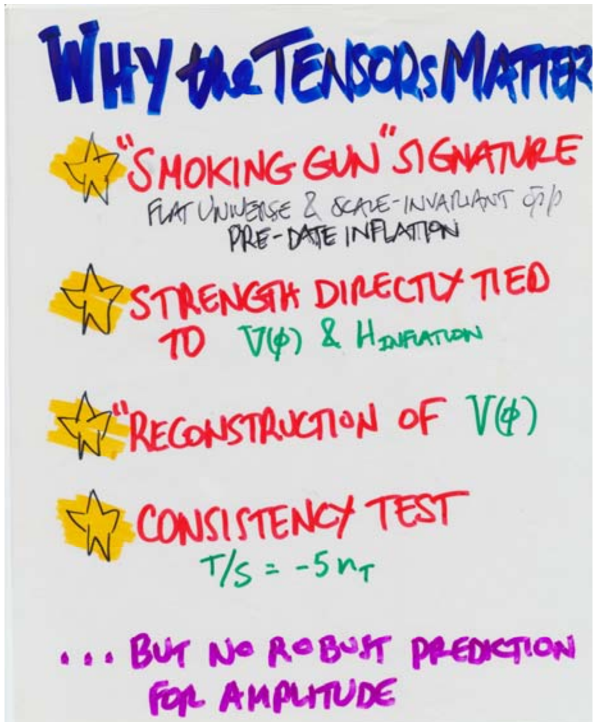
Michael S Turner
Director and Rauner Distinguished Service Professor
Kavli Institute for Cosmological Physics

Today, BICEP2 announced evidence for the CMB B-mode polarization signature of inflation-produced gravitational waves. If this result holds up, March 17th, 2014 will go down in cosmic history as day as important as when COBE announced the discovery of CMB anisotropy (April 23rd, 1992) or when the Supernova Cosmology Project and the High-z Redshift team announced that the expansion of the Universe is speeding (in early 1998). It will remembered as a day that divides cosmology into a before and after March 17th.



So what is the big deal. Inflation makes three key predictions: flat universe, almost scale-invariant density perturbations and gravitational waves. For more than 20 years I have referred to the third prediction as the smokin' gun of inflation – and for good reason! The first two predictions – flat Universe and scale-invariant density perturbations – had already been discussed as features of any sensible cosmological model. Gravity waves are a new prediction.



Moreover, their amplitude immediately reveals the epoch of inflation and the energy scale associated with inflation:

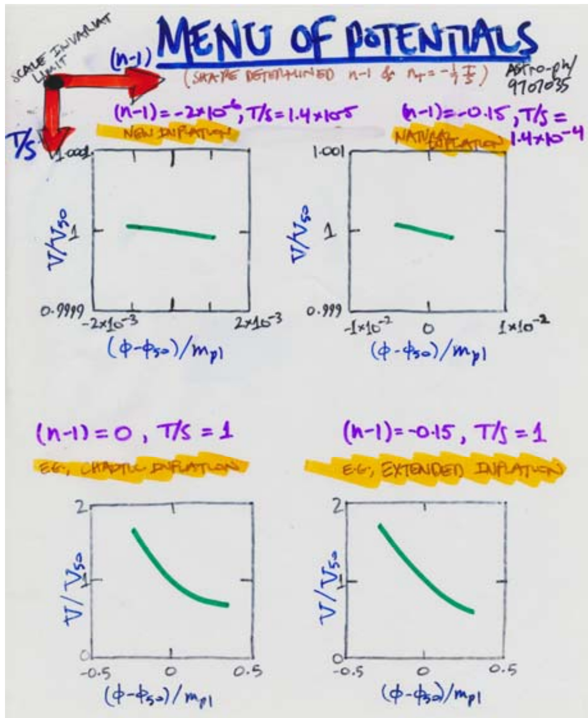
$$H_I^{-1} = \frac{2 \times 10^{-39}\,\mathrm{sec}}{\sqrt{T/S}}$$

$$V^{1/4} = 3 \times 10^{16}\,\mathrm{GeV}\,(T/S)^{1/4}$$

For the BICEP2 result, r = T/S ~ 0.2 that the timescale and energy are about 10^{-38} sec and 10^{16} GeV respectively. This corresponds to a very early epoch of inflation and a very-high-energy scale for inflation, comparable to the scale of unification suggested by supersymmetric grand unified theories. Needless to say, particle theorists will be very interested as the energy scale being probed is well beyond what accelerators have been able to probe and close to the stringy scale.

Further, the level of gravitational waves also provides information about the scalar field and its scalar potential. In particular, for a level this high it indicates that the scalar field varied during inflation by amount comparable to the Planck mass (1.22 x 10^{19} GeV) [*Phys.Rev.D* **48**, 5539 (1993)]. Further, if we add the deviation from scale-invariance (n-

1 = 0.96 ± 0.0073) that has been measured, the simplest models (e.g., $m^2\phi^2$, $\lambda\phi^4$ or natural inflation) would be called out as the most interesting. (The authors of natural inflation include our own Angela Olinto, Josh Frieman and UChicago grad Katie Freese now at UMichigan.)



That being said, there is a possible spoiler at this party. Previous limits to the level of the gravitational waves based upon CMB temperature anisotropy data alone, set a 95% cl limit on r of 0.11, in conflict with this detection (Story et al 2013 http://arxiv.org/abs/1210.7231). There is one way (possibly more) to reconcile the two apparently contradictory results: running (or a variation in the power law index of the density perturbations). However, larger than expected running is required (dn/dlnk ~ -0.02 vs. the typical 0.001 predicted by most models of inflation).

Because the B-mode signal is so loud (almost a microkelvin!), a number of experiments will be able to confirm or refute it and hopefully extend the measurements very soon (including our own South Pole Telescope). Planck may weigh in soon – they appear to have the sensitivity to see this and have all-sky data.

This is exciting! I am ready to be a 20-something year old postdoc again.

Finally, my thoughts turn to the late Andrew Lange, whose legacy lives on in the BICEP2 detectors. Andrew used to talk about the apparent folly of chasing the wild goose of the B-modes. He was a true friend and a true believer; I wish he were here to share in today's excitement.

For now, this last slide says it all!