Personal reflections on the BICEP gravity wave results

Andreas Albrecht

March 22, 2014

What a thrilling result[1]! My head has been spinning all week… it is a huge challenge just trying to fully appreciate the implications of this result, assuming it is confirmed.

To start with, it is amazing to think that the picture, slow roll inflation, that Paul Steinhardt and I proposed in that little paper back in 1982[2] (and which was independently proposed by Andrei Linde[3]) is now something most physicists think must have really happened in the early universe.

Back in the 80's, it was thrilling to work with such adventurous new ideas, but the ideas were so new and exotic it seemed a stretch to think that nature might have actually chosen to work that way. A few decades later, it is even more thrilling to contemplate the huge amount of evidence that nature really does seem to have chosen to inflate!

But my excitement extends way beyond those points: Although inflationists long believed the gravity waves should be there, we had no idea how strong the signal would be, or whether it would be strong enough to see in our lifetime, or even many lifetimes into the future. So it is amazing to learn that nature has been incredibly generous with us, and chosen a path where the gravity wave signal is about as strong as it could be. Of course the reason we were so uncertain about the expected signal strength is that there are so many inflation models that predicted lower signals. A huge bonus of this result is that all these models are now ruled out, greatly narrowing down the possibilities (and thus increasing our understanding) of how inflation actually works.

An even bigger bonus: The strength of the gravity wave signal opens up a whole new field of Gravity Wave Astronomy. So far we have viewed the cosmos almost entirely using light waves[4]. Because the early universe was opaque to light there is a limit to how far back we can use light waves to view the early universe directly, a kind of "wall of opaqueness" (aka the "surface of last scattering[5]"). Gravity waves are like having "x-ray vision" that can see right through this wall of opaqueness and look very deep into the beginnings of the universe. People have already envisioned and planned exciting new telescopes to do gravity wave astronomy. Some have already been built and are taking data, larger ones are in the planning[6] or dreaming[7] stages. Before, it was not clear there was a signal that these

---

[1] http://bicepkeck.org/
[2] http://inspirehep.net/record/176612?ln=en
[3] http://inspirehep.net/record/168781?ln=en
[4] Just last year, the field of Neutrino Astronomy began: http://physicsworld.com/cws/article/news/2013/dec/13/cosmic-neutrinos-named-physics-world-2013-breakthrough-of-the-year
[5] http://universeadventure.org/eras/era2-synthesis.htm
[6] http://sci.esa.int/ngo/, http://lisa.nasa.gov/
[7] http://en.wikipedia.org/wiki/Big_Bang_Observer

ambitious telescopes could detect. The BICEP result tells us that there is, making the case much stronger to go ahead with these impressive projects. No doubt Gravity Wave Astronomy will take us on amazing new adventures, and will certainly give us an even clearer look at cosmic inflation.

And if all that is not enough: The gravity waves from inflation are produced in a deeply quantum mechanical way, giving us a window on the quantum nature of gravity which overall is a challenging problems that continues to puzzle physicists.

Most of us were inspired to work on cosmic inflation by a seminal paper by Alan Guth[8]. In that paper Guth argued that inflation would solve various "fine tuning" problems associated with cosmology. Interestingly, it is not yet clear if inflation really can solve the tuning problems. The new evidence supporting cosmic inflation makes it all the more compelling to wrestle with these challenging questions, an important topic of my own current research[9]

On a more personal note, this week was a complicated one for me, because as chair of the Astronomy and Astrophysics Advisory Committee[10] I was responsible for finalizing our 2014 report (turned in on Wed.) You cannot imagine two more different mental activities, facing the profoundly exciting BICEP results, and dealing with the minutia of finalizing the report[11]

A large group of us (including Lloyd Knox, Tony Tyson and many graduate students active in this area) gather Monday morning to try to hear the announcement and study the papers online. In a move of brilliant (but completely accidental) timing, we hosted a beautiful colloquium talk by Justin Khoury[12] on the afternoon of the BICEP announcemnt, in which he was able to show the huge impact the BICEP results have on our understanding of the cosmos (including eliminating a host of non-inflationary theories on which Justin is an expert). Then on Thursday we hosted an impressive public lecture by Brian Greene[13], who was able to share the excitement of the new results in front of a huge and enthusiastic audience.

Finally (as noted in the dedication of the BICEP paper), this is a bittersweet moment when we all salute and miss Andrew Lange, the visionary leader of the BICEP team who met an untimely death in 2010. My emotions have been particularly extreme as Tuesday I also marked the 6th anniversary of the untimely death of my dear son William. There are no guarantees that life will be easy, but all the more reason to appreciate when amazingly good things happen. It is with profound appreciation that I reflect on the events of this past week.

---

[8] http://inspirehep.net/record/154280?ln=en
[9] See for example http://arxiv.org/abs/arXiv:1401.7309
[10] http://www.nsf.gov/mps/ast/aaac.jsp
[11] The report is a good one however, and will probably have a role in helping us build the ambitious gravity wave telescopes of the future, as well as many other amazing facilities.
[12] Like me, a Steinhardt PhD student: http://www.physics.upenn.edu/people/standing-faculty/justin-khoury
[13] http://mondaviarts.org/events/event.cfm?event_id=1322

Back to my main page: http://albrecht.ucdavis.edu/