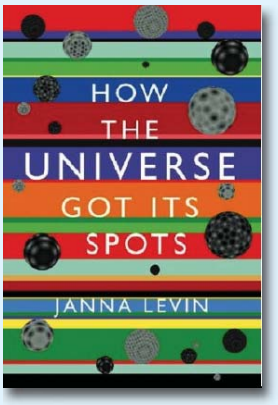
Big Bang Books



How the Universe Got its Spots

Janna Levin

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Phoenix

Summary

How the Universe Got its Spots, subtitled Diary of a Finite Time in a Finite Space, is Janna Levin's first book. It's a highly personal account of her life as a theoretical physicist in the period between September 1998 and January 2001 and the challenges she faces trying to balance the work that drives her and the relationships that sustain her. Very few writers have produced a popular science book that is a true page turner, but Levin succeeds where others have failed because she makes us care almost as much as she does about the subjects she touches on. In this book, Levin makes physics human.

Written in a diary format and initiated by a desire to explain to her mother what she does – "I'm writing to you because I know you're curious but afraid to ask" – Levin sets out to answer the question 'is the universe infinite?'. Or at least to show her mother, and us, why this question is so intriguing that it's worth leading a rootless and chaotic life that leaves Levin constantly wondering whether she has her priorities right.

The book is a breakneck journey through the major ideas in mathematics and physics since antiquity. Simply listing a few of the topics she covers is intimidating: Pythagorean number theory, Newtonian physics, non-Euclidean geometry, transfinite arithmetic, electromagnetism, special and general relativity, quantum mechanics, black holes, quantum gravity and string theory. But by melding gossipy anecdotes about people with clear and concise explanations of their ideas, Levin avoids lecturing and succeeds in engaging us and creating some genuine 'oh right!' moments.

All this background information sets the scene for the main event – working out the topology, or shape, of the universe and how we will be able to tell whether the universe is infinite or finite. By encouraging us to imagine what it would be like living in a one- or two-dimensional world, Levin enables us to start getting to grips with ideas such as worlds with more than three dimensions and what it means to say that the universe has a shape. We also start to understand why asking the question is important.

By the end of the book, Levin hasn't found the answer to her question and is eagerly awaiting the experimental results of two space-based experiments (WMAP and Planck Surveyor). Her life is as chaotic as ever – although the epilogue does hint at reconciliation with her partner and a more settled life back in the US – and we are left hoping that she finally finds what she is looking for. Both as a physicist and as a person.

Update from the author

Despite my interest in the possibility of a finite universe, I would have been shocked if the universe had turned out to be small. The universe can be finite but huge, so huge that not even light emitted at the time of the big bang has had a chance to cross the whole cosmos in the intervening 14 billion years. If instead the universe is small – small enough that light has had a chance to travel around the cosmos multiple times – then we could see a distinct signature of a finite space imprinted in a pattern in the light left over from the big bang. This is similar to seeing a pattern in a hall of mirrors.

When data from the Wilkinson Microwave Anisotropy Probe (WMAP) came back with beautiful observations of the light left over from the big bang, there was only one peculiar feature and that feature just happens to be the characteristic signature of a small universe. This caused some renewed interest. The initial excitement however has subsided since none of the detailed searches for evidence of topology turned up any kind of further support for a small universe.

The universe can be very big but still be finite. There are other reasons to be interested in the shape and size of the universe. String theory, for instance, suggests that the universe has more than three spatial dimensions, that there may be 10 or more, and that these additional spatial dimensions are not only finite but unobservably small – in some scenarios smaller than the size of an atom. It seems fair to imagine that the universe began with all of the spatial dimensions small and then to wonder how three became large while the others remained curled up. Working with string theorist Brian Greene, I've been investigating how the universe we live in could evolve to be three dimensional and huge as a result of the squeezing of several extra spatial dimensions.

Warren and I live in New York and have two kids, a 4 year old boy and an 11 month old girl.
Janna Levin, July 2007

Some science questions raised by the book

What results are there from WMAP and Planck Surveyor?

WMAP observed the faint 'glow' of microwave radiation left over from the big bang (the so-called cosmic microwave background radiation), trying to get clues about the shape of our universe. Some scientists claimed that the data shows the universe to be finite. Others have disputed these findings. The problem is that the effects are tiny and measurements are very difficult. There are other sources of microwave radiation in the sky, such as our own galaxy, and these have to be subtracted from the overall set of data. It is like taking a photo of the night sky from a street in central London, digitally removing the light from street lamps and then trying to work out the constellations.

The Planck Surveyor is due to be launched in July 2008 and its mission will be to analyse in even greater detail the cosmic microwave background radiation. For an interview with Prof Joseph Silk, one of Janna's collaborators, about the topology of the universe and the Planck Surveyor's role see
http://www.esa.int/esaSC/SEMR53T1VED_people_0_iv.html

If the universe is finite, then what is 'outside' it?
Some theories put forward the idea of the existence of multiple universes (the so-called 'multiverse' hypothesis). There might even be ways to kick-start a new universe in a laboratory and have it expand in its own space, completely disconnected from our own universe. The problem with these universes is that there is no way for us to communicate with them. So, although the question is not meaningless, it is hard to give an answer beyond mere conjecture.

Does it actually matter whether the universe is finite or not?
No more than it matters whether the Earth is flat or round, as long as you are only interested in measuring the surface of your back garden. The curvature of the Earth can be ignored when you're dealing with distances that are small compared to its diameter. In the same way, the exact shape (or 'topology') of the Universe can be ignored on relatively small scales (say within our galaxy).

However, finding out the true shape and extent of our universe is part of a voyage of discovery that is driven by our collective curiosity about our origins. And only when we know as much about our environment as we can, will this curiosity be satiated.

Some things to talk about

1. Janna describes her life as chaotic – how is this reflected throughout the book? Do you think that being a physicist makes her life more complicated than it would be otherwise? Or would she be in a similar situation if she were, for example, an artist or an admin assistant?

2. How does the format of the book help to drive forward the narrative? Is Janna totally successful in her use of diary entries as a conceit? What other techniques does she use in order to keep you turning the pages?

3. Janna intimates that she is isolated by her rarified knowledge; by the fact that very few people understand what she does all day. Are scientists the only people who might experience this?

4. How are scientists portrayed in the book? Janna claims to dislike hagiographies, but she clearly admires Einstein (and many others). Does her self-proclaimed obsession with the suicidal tendencies of mathematicians add anything to the narrative?

5. Janna's persistent name-dropping highlights the collaborative nature of science and how breakthroughs are rarely achieved in isolation. Does this fit with your image of what science is?

6. Have you read any other popular science books? If so, how does this one compare? Would you recommend it to a friend? Are you more likely to read other, similar books now?

Some more books to read

Brief History of Infinity: The Quest to Think the Unthinkable *Brian Clegg*. ISBN 1841196509. Robinson Publishing.

The Fabric of the Cosmos: Space, Time and the Texture of Reality *Brian Greene*. ISBN 0141011114. Penguin.

Flatterland: Like Flatland Only More So *Ian Stewart*. ISBN 073820675X. Perseus Books.

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