Cosmic 'the galaxies form great daisy chains...wrapped like Christmas lights around dark voids of mind-numbing emptiness'

The Cosmic Web: Mysterious Architecture of the Universe

By J. Richard Gott
Princeton University Press
272pp, £22.95
ISBN 9780691157269
Published 9 March 2016

Is the universe like a meatball stew or is it like Swiss cheese? It sounds like a ridiculous question. However, the answer, says Richard Gott, reveals what was going on in the first split second of the Big Bang.

Gott, a professor of astrophysics at Princeton University, is also author of *Sizing Up the Universe*, in which he helped people really get their heads around the scale of the universe and the objects in it. It is one of my favourite popular science books (I don't get out much). *The Cosmic Web* is a continuation of Gott's obsession with the large-scale universe, but at a semi-popular/semi-technical level.

Imagine sitting in a field in a deckchair from which you can never move and trying to deduce everything about the planet you live on. Astronomers find themselves in a very similar position. They can never leave the Earth and must deduce the structure of the universe only from the thin rain of cosmic photons bringing news to them of distant stars and galaxies.

Given these crippling limitations, it is extraordinary that astronomers have discovered both the extent and content of the "observable universe". With their telescopes, they can see all the way to the "light horizon" that bounds space and they can count up the building blocks contained within it – about 100 billion galaxies, of which our Milky Way is but one. And not only do astronomers know the extent and content of the universe, they know where it all came from. It burst into being in a blisteringly hot fireball 13.82 billion years ago. The galaxies congealed out of the expanding and cooling debris. It is a picture of our universe that previous generations would have killed for.

Gott describes all of this with clarity, charm and infectious enthusiasm. Inexplicably, however, he maintains that, because the age of the universe is 13.82 billion years, the distance to the edge of the observable universe is 13.82 billion light years. In fact, it's about 42 billion light years since space expanded far faster than light – something permitted by Einstein's general theory of relativity – during its initial "inflationary" phase. A tiny flaw in an otherwise excellent book.

It is the distribution of galaxies throughout space that provides the vital clue to the origin of the universe, says Gott. He describes in fascinating and comprehensive detail the Herculean task that astronomers have been engaged in in order to figure out that distribution. Far from being spread evenly through space, the galaxies form great daisy chains and sheets, wrapped like Christmas lights around enormous dark voids of mind-numbing emptiness.

The distribution of galaxies, it turns out, is neither like a meatball stew, in which voids dominate, or Swiss cheese, in which matter dominates. Instead, it confirms Gott's long-held prediction that it is a cosmic web – a sponge-like structure whose unique property is that it would look the same if the voids were switched with galaxies, and vice versa. Crucially, this supports the idea that the primordial seeds of cosmic structure were sub-microscopic "quantum fluctuations" in the first split-second of the universe's existence – in their randomness, as likely to spawn denser-than-average regions as less-denser-than-average regions in the Big Bang fireball.

The galaxy you live in, says Gott, came from a seed far smaller than an atom. Who said science isn't stranger than science fiction?

Marcus Chown, formerly a radio astronomer at the California Institute of Technology, is author, most recently, of *What a Wonderful World: Life, the Universe and Everything in a Nutshell* (2014).