What have the stars done for humankind?

December 20 2023, by Bryony Ravate

Professor Roberto Trotta. Credit: Imperial College London

Professor Roberto Trotta from Imperial College London's Department of Physics is a theoretical physicist by training and astrophysicist by trade. His work explores how statistics and machine learning can help us turn complex datasets from telescopes on Earth and in space into real-

life understanding.

Almost four years ago, he gave his inaugural lecture at Imperial. Now, he is a Visiting Professor who wants to empower us to appreciate the sky and the stars. His newest book, "Starborn," was recently featured as BBC Radio 4's Book of the Week.

We spoke to him to find out what the stars, sky and everything in-between bring to humankind, and why we should strive to look after our planet so we can still look up to the stars.

When I think of space scientists, machine learning and big data are not what initially spring to mind. Can you explain why we use big data and AI to examine the world above us?

Machine learning and artificial intelligence have become essential in learning about our universe. Galileo and others once looked through the telescopes and drew what they saw, and years later at the Harvard Observatory women astronomers inspected hundreds of thousands of stars and galaxies through images. Because of the complexity and sheer scale of the data that we have now, we need computers to extract scientific meaning from the deluge gathered from telescopes in space and on Earth.

One of the big cutting-edge frontiers of my field is precisely that. We explore how artificial intelligence (AI) can understand the universe for us. We're getting more and more data all the time, but the question is what does it all mean? And that's where the statistics and machine learning come in.

Can you explain to me what you're trying to find out,

and what people hope to find out with this work?

Different people are interested in different things. My research focuses on three main areas: what happened in the first fraction of the second of the Big Bang, how dark matter and dark energy behave, and understanding what the universe is made of.

The universe is made of 25% dark matter and 70% dark energy—which together make up a whopping 95% of the universe—but we have little clue as to what they are.

We owe our existence to the gravitational pull of dark matter. It played a crucial role in enabling galaxies and stars to form, especially at the rapid speed they did. We're pretty sure dark matter exists, because we see it affects the way the universe expands, and the way galaxies move. The question is what is it made of?

Dark energy is much harder to explain. We see the universe growing faster and faster and we think that is caused by a repulsive force, an anti-gravity. And this is perhaps because of the property of empty space itself; as the universe expands it creates more empty space, which in turn leads to more repulsive forces so it expands even more rapidly. We think this runaway expansion process is powered by dark energy, but nobody understands what it is. And we're trying to find out.

I can't comprehend how you would investigate the first milliseconds after the Big Bang, because it's such a small time frame for something so long ago. How do you do this?

We now have observations from very, very early on in the history of the universe, radiation that comes from 380,000 years after The Big Bang.

The universe has 13.8 billion years under its belt, so 380,000 years after the beginning is a fraction of its age. Thanks to these observations, we can go back almost to the very beginning.

We're pretty sure that we can reconstruct almost everything up until that point. But what happens there? That is the big question.

We think the universe expanded very, very fast at an exponential rate in a very small amount of time. We call that moment "inflation," and we're trying to reconstruct what that tiny fraction of a second looked like, and what it was triggered by.

Although this was much higher energy than what's happening today with dark energy, it was the same effect—exponential expansion. The two things might or might not be linked.

Only 5% of the universe is made of stuff that you and I are made of. That's one of the big questions in physics. What is the rest of the stuff and why does it exist? Why is the universe so weird?

What have you discovered so far about the universe and its weirdness?

Science is always a collaborative enterprise, so you build on the shoulders of giants. I have very talented younger researchers who work with

me in my group, and collectively we want to give answers to these questions in a way that uses all the information available in the data with a result you can trust.

It's very statistical and computational and we are always seeking how we

can get this information out of complex datasets.

Your book is all about looking up to the stars—which I assume you've done a lot of—and appreciating what stars have done for humankind.

A –Yes, we're all made of stardust—but stars have done so much more for us than that. The book is not about the physical nature of the stars or dark matter or any of the things that we have talked about so far. The book is about the cultural impact that seeing the stars has had on humankind, from the very moment when Homo Sapiens walked out of Africa 50,000 years ago, to AI today. The stars have a great deal to answer for in terms of the inspiration and knowledge they have given us.

You drew a comparison between Homo Sapiens 50,000 years ago to AI today. Would you say that this impact of the sky and the stars is just as great as it was 50,000 years ago?

We're losing the sky and our connection to the sky, and you might ask is it important? I think yes, it's very important. When we lose the sky, we lose an awareness of our deep connection going back to prehistory.

We're very busy now, we live in cities, we don't look up and we don't care about the stars anymore, 150 years ago you could see the Milky Way from London. Now, you hardly see any stars at all. Even where I am currently in Trieste, Italy, where the sky is quite dark, you see lots of passing satellites, which by some estimates will outnumber the stars by 2030.

What happens when we lose the stars?

By losing the connection, you lose the significance of our place in the universe and the meaning that it holds for countless generations. This endangers not just the present, but our future too.

We lose the sense that we are a blue dot floating in a vast, inhospitable dark universe, and that we are far away from any other place that we could call home.

Our planet is irreplaceable, there is no Planet B, and we cannot colonize Mars, not on the time scale that we need it. We need to get our act together because losing the stars means also losing ourselves.

Is your goal here to empower people to look up?

I want to empower people to look up to the stars but also to think about our trajectory and mark on the universe. Even as early as 50,000 years ago, we changed our environment to suit us. Now, there is a sense of danger through the loss of biodiversity and climate change. By taking this very long view of the entire arc of history of humans and how the stars have led us, and hopefully looking up at the stars for more inspiration for the future, we should think: "Where do we go from here?" Rather than to the stars or Mars, we need to reclaim the uniqueness and beauty of our place in the universe, our own planet, now.

Would it be dangerous for humankind, if one day we looked up to the sky and we were met with a vast blackness, instead of stars?

It wouldn't necessarily be dangerous, but we would all be poorer. Imagine a world where a veil of clouds enshrouds the sky, as I do in Starborn, and nobody has ever seen a star, the sun or the moon. It may not be dangerous, but certainly, it wouldn't be quite as enriching.

I see you've done quite a lot of science communication in the past. Is educating others a passion of yours?

It's something I have always done, and always felt like it's my duty as a scientist. I want to give back some of that excitement, passion and enthusiasm that we as scientists are lucky to pursue as our main line of work.

It's a great honor to share that with the public.

How do you feel about your book being nominated as Book of the Week?

It's an incredible honor, of course, and I wasn't expecting it. I would like my book to help deflate the myth of a Planet B we can escape to and contribute to conversations about the urgency of protecting our planet.

We must pay attention to what's happening here and now, the next generation won't have the stars and might not even have a planet to live on. To me, that is the important message.

More information: Starborn: How the Stars Made Us (and Who We Would Be Without Them). www.hachettebookgroup.com/titl … 76/?lens=basic-books

Provided by Imperial College London

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