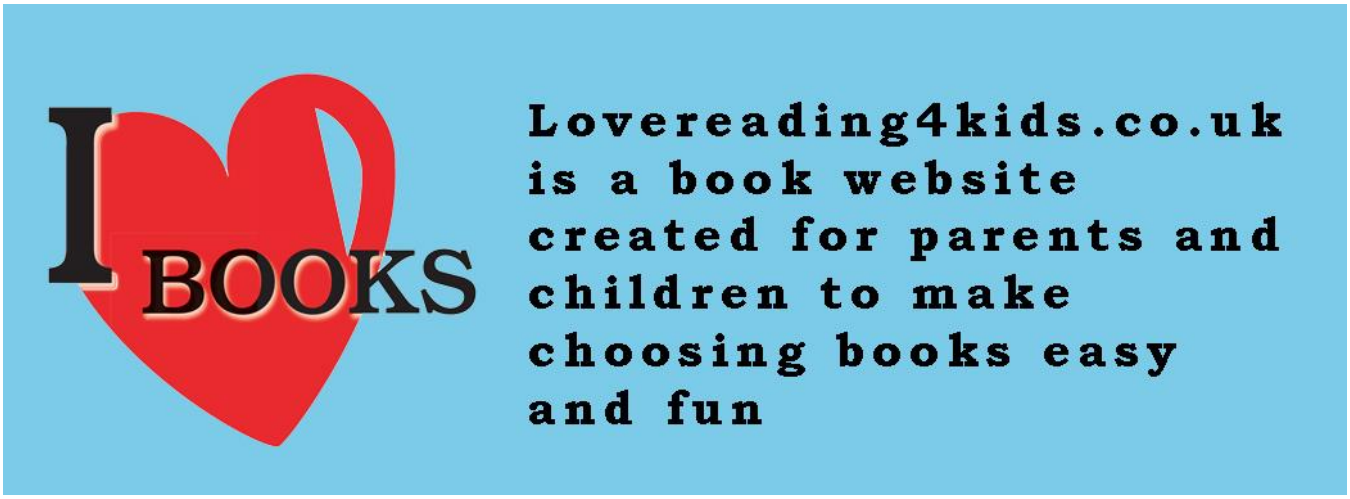


Opening extract from

# 50 Things You Should Know About Space

Written by

**Raman Prinja**

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Words in **bold** are explained in the glossary on page 78.

To Kamini, Vikas and Sachin - RKP

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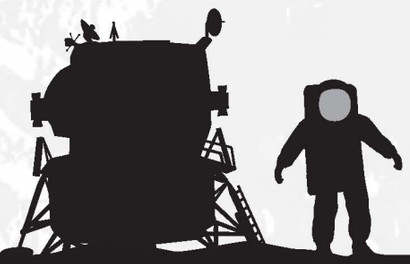


There are more stars in the Universe than there are grains of sand on Earth's beaches.

# INTRODUCTION

**Since the invention of the telescope just over 400 years ago, our knowledge of the Universe has grown enormously. Today, astronomers can see farther than ever before, studying stunning objects far out in the Universe in incredible detail. Spacecraft have journeyed to distant worlds and humankind has travelled into space and even set foot on the Moon.**

▲ *Images such as this one, of two colliding galaxies measuring 180,000 light years across, have helped astronomers to understand the true vastness of space.*

## VAST DISTANCES

Space is very big. To get an idea of just how big, imagine a scale model where the Sun is the size of a basketball. The Earth would be a pea about 32 metres away, while the next nearest star would be another basketball almost 9,000 kilometres away. It would take another 200 billion basketballs just to make a model of our own **Milky Way** galaxy. And there are at least 100 billion galaxies in the Universe.

## STUDYING SPACE

Our understanding of the Universe depends on our collecting, studying and explaining the very faint light reaching us from distant parts of our **galaxy** and beyond. To do this, astronomers use powerful telescopes, both on the ground and in space, as well the latest computing and engineering technology.

◀ *In the 16th century, Italian scientist Galileo (centre, standing) became one of the first people to study space using a telescope.*

▶ *The modern successor to Galileo's telescope, the* **Hubble Space Telescope**, *orbits Earth taking images of deep space.*

## EXPLORING SPACE

To study other worlds in greater detail, scientists have launched numerous spacecraft on amazing voyages across the **Solar System** to explore planets, moons, **comets** and **asteroids**. People have also been sent into space, **orbiting** the Earth, living in space stations for months on end, and even setting foot on the Moon during the **NASA**-run *Apollo* missions. Between 1969 and 1972, 12 **astronauts** visited the Moon as part of six separate missions, marking humankind's first (and so far only) visits to a world other than Earth. However, scientists believe it may be possible for astronauts to travel to Mars and back in the future.

▼ *The U.S. astronaut Buzz Aldrin steps down onto the Moon in 1969.*

▲ *Some of the spectacular images of galaxies, nebulae and stars captured by the* **Hubble Space Telescope** *in the past few decades.*

## NEW DISCOVERIES

Astronomers watch the Universe's most powerful events being acted out, from massive **black holes** tearing apart stars to galaxy collisions. New space discoveries are being made all the time, such as the thousands of planets now known to be orbiting distant stars and the mysterious force of **dark energy** that is believed to be pushing the Universe apart.

# 1 The Universe is expanding

**The Universe is all of space and everything in it, including galaxies, stars, planets, moons and living things. It is everything we can see and measure, making it almost unimaginably vast – and it's getting bigger all the time. Scientists believe the Universe is still expanding at an ever increasing rate.**

*Powerful telescopes have allowed us to take images such as this one showing some of the farthest galaxies from Earth, which formed shortly after the Universe began.*

## THE HISTORIC UNIVERSE

The ancient Greek astronomer Ptolemy (90–170 CE) came up with a model of the Universe with the Earth at its centre and all the planets and Sun orbiting around it. Known as the 'geocentric Universe', this idea lasted for centuries. But in the early 16th century, the Polish astronomer Nicholas Copernicus (1473–1543) devised a new model. After carefully studying the night sky, he placed the Sun at the centre of the Universe, and had the planets moving around it. This is known as a 'heliocentric Universe'.

*Geocentric Universe*

*Heliocentric Universe*

*▲ Much of our understanding of the Universe is based on the studies of gravity by the English scientist Sir Isaac Newton (1643–1727).*

## MOVING APART

The Universe has grown larger and larger since it began around 13.8 billion years ago. Incredibly, the space we see today is almost a billion times bigger than it was when the Universe was very young. As the Universe continues to expand, so the space between galaxies is also being stretched apart and the galaxies are moving farther away from each other. This is known as an 'expanding Universe'. Neither the Earth nor the Sun lie at its centre, because the Universe does not have a centre.

## UNDERSTANDING THE COSMOS

Our understanding of what the Universe is and how it works has improved vastly through the centuries. Over time, astronomers have made better measurements of objects in the sky, built more powerful telescopes and even put some of them in orbit around Earth. Our knowledge of related subjects, such as physics and mathematics, has also increased.

*◀ This observatory is located on a mountain in Hawaii where the air is clear and there is little light pollution.*

## BILLIONS OF GALAXIES

It is estimated that there are more than 100 billion galaxies in the Universe. That's the number 1 followed by 11 zeros. And there are on average about 100 billion stars in each galaxy. That means that the number of stars in the Universe is so huge it has to be written down as a 1 followed by 22 zeros. Perhaps even more incredibly, the Universe is so large that even with these vast numbers of galaxies and stars, most of space is empty.

**Vast distances**
Special units called light years are used to measure the enormity of space (see page 8).

**Big Bang**
Scientists believe the Universe expanded from a single point. (see page 9).

**Fraction of time**
Humans have been around for just a tiny part of the Universe's 13.8 billion year history (see pages 10–11).

**Dark matter**
Most of the Universe is made up of the strange, little-understood substance, dark matter (see page 12).

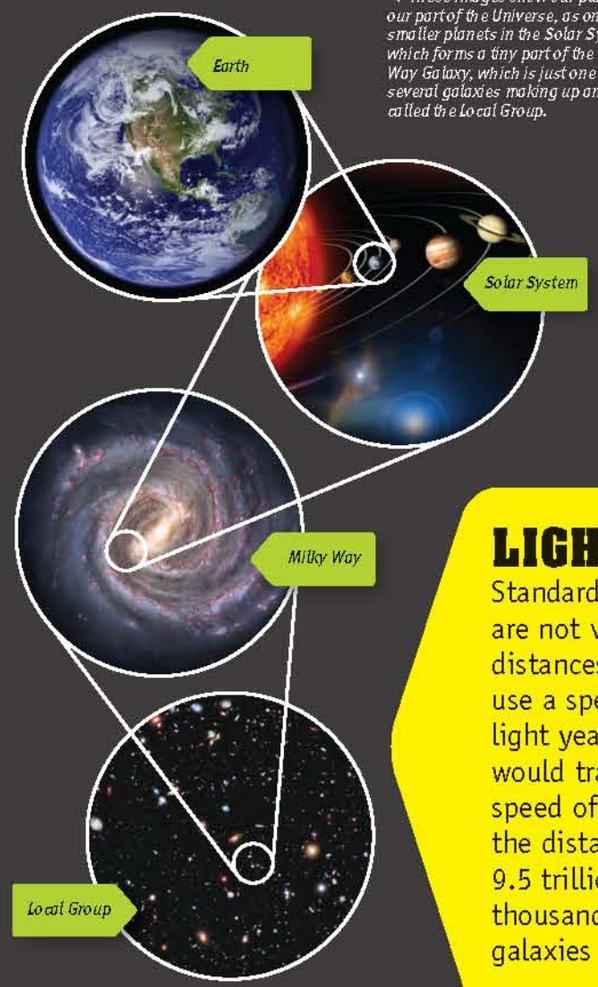
**Dark energy**
The mysterious force of dark energy is causing the Universe to expand ever more quickly (see page 13).

**Bang or whimper?**
Scientists have developed several theories about how the Universe might end (see pages 14–15).

2

# Measuring space

**Space is immense and the distances between objects in the Universe can be enormous. The Earth's Moon is 384,400 kilometres away from us, the Sun is 150 million kilometres from Earth, while our most distant planet, Neptune, is around 4.5 billion kilometres from the Sun.**




*◀ These images show our place in our part of the Universe, as one of the smaller planets in the Solar System, which forms a tiny part of the Milky Way Galaxy, which is just one of several galaxies making up an area called the Local Group.*

## LIGHT YEARS

Standard distance units, such as kilometres, are not very useful for measuring the vast distances in space. Instead, astronomers use a special unit called a **light year**. One light year is equal to the distance light would travel in one year. Since light has a speed of 300,000 kilometres per second, the distance it travels in one year is about 9.5 trillion kilometres. Some stars are thousands of light years away, while some galaxies are billions of light years away.

## OUR NEAREST NEIGHBOUR

The numbers start to get even more mind boggling when we go beyond the Solar System. The nearest star to the Sun, Proxima Centauri, is an incredible 41 trillion kilometres away. That's the number 41 followed by 12 zeros. And other stars are much farther away than that.

*▲ Proxima Centauri, the closest star to our Solar System, is 4.3 light years from Earth.*



# The Big Bang

3

**Most scientists today believe that the Universe started about 13.8 billion years ago with a powerful event known as the Big Bang. Matter, space and even time all began at this moment. The idea that the Universe began in this way is called the Big Bang Theory.**

*▼ An artist's impression of how the Universe expanded from a single point following the Big Bang.*

## THE FIRST INSTANT

The Universe began as a single point that was very hot and dense. Just a tiny fraction of a second after the Big Bang, the Universe had a temperature that, if written down in celsius, would be the number 1 followed by 32 zeros. From this moment on, the Universe grew at an incredible speed.

## PARTICLES

Within seconds, the Universe had stretched out and begun to cool down. After about 100 seconds, particles such as electron, protons and neutrons had started to form. These are the particles that make up **atoms**.

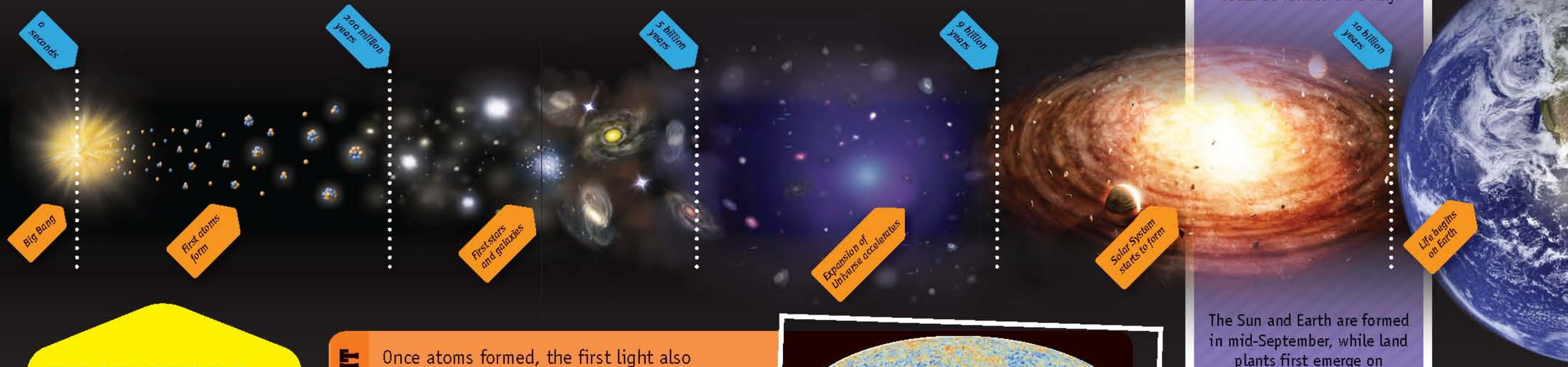
4

# The history of the Universe

**Since its beginning 13.8 billion years ago as an unimaginably hot and dense point, the Universe has gone through several important stages to become the vast structure we see today, made up of 100 billion galaxies racing away from each other.**

## INSTANT INFLATION

Scientists think that a fraction of a second after the Big Bang, the Universe went through an incredible change when it expanded even faster than the speed of light. This special and very brief period in the history of the Universe is known as inflation. During inflation, the Universe doubled in size almost 90 times.

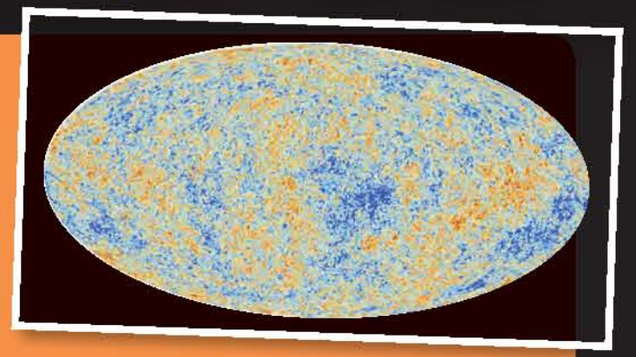



## FIRST ATOMS

After about three minutes, the nuclei of simple **elements** such as hydrogen and helium formed out of the protons and neutrons that had appeared earlier (see page 9). The first atoms formed about 380,000 years later.

## FIRST LIGHT

Once atoms formed, the first light also appeared. Known as 'cosmic microwave background radiation', it can still be detected today, though it has now cooled down to a freezing -270°C. This radiation is very important to astronomers because it tells them a great deal about how the Universe came into being and the changes that happened when it was very young.



▲ *This is an image of cosmic microwave background radiation – the oldest light in the Universe. The hotter areas, where superclusters of galaxies would later appear, are marked in orange.*

## STARS AND GALAXIES

The first stars and galaxies started to form about 400 million years after the Big Bang, although it would be another nine billion years before the Earth and Solar System appeared. Over the first few billion years, matter was pulled together by **gravity** to make huge numbers of galaxies, which in turn formed vast groups called clusters and superclusters. Other parts of the Universe had much less matter and very few galaxies. These almost empty parts of space are known as voids.

## COSMIC YEAR

To help us understand how the Universe has changed since the Big Bang, imagine that the 13.8-billion-year history of the Universe is condensed down into just one year. Each month equals a little over a billion years. So, 1 January in this imaginary year would mark the Big Bang itself. The first stars would appear on 20 January and our Milky Way galaxy would be formed on 1 May.

The Sun and Earth are formed in mid-September, while land plants first emerge on 19 December. The dinosaurs appeared on 25 December, but were wiped out by a comet crashing into Earth on 29 December. In this model, the whole history of human civilization would fit into the last 20 seconds of the year.