Chapter 1

Exploring the Early Universe

In This Chapter

- Pondering the very beginning of the universe – and beyond
- Looking to science and religion for explanations
- Introducing cosmology
- Appreciating this current moment of cosmological discovery

Nothing is more human than wondering where you come from.

Just look at your average 3-year-old: They like nothing more than to embarrass their parents by asking them how they were born (and why that lady over there is wearing such a funny-looking dress).

Pondering the mysteries of the universe is also ingrained in growing children. One of the first nursery rhymes children recite is 'Twinkle, Twinkle Little Star', which contains the simple yet profound line 'How I wonder what you are'. And children's earliest attempts at art often include pictures of the Sun and the Moon – made more friendly with the addition of smiling faces, of course.

Little surprise, therefore, that by the time children are pre-teens – and sniggering over technical diagrams of human procreation – they are simultaneously starting to ask deeper questions about the skies: Why is it blue? Why do stars only shine at night? Are the Sun and the Moon the same every night or do they pile up in a discarded heap beyond the horizon? Films like *ET* and *Star Wars* only help to fuel the curiosity.

That curiosity that doesn't vanish with childhood, either. As an adult, you may find yourself pondering the multitude of stars in an especially dark night sky, or being caught off-guard by a particularly beautiful moon. If any of this sounds familiar, then *The Origins of the Universe For Dummies* is definitely for you.

Shifting Views – Scientifically Speaking

Imagine for a moment that you're a pupil at school in the first few years of the 20th century. At this time, the most famous scientist in the world is still probably Sir Isaac Newton (turn to Chapter 3 for more on Newton). Several years still need to pass before the name Albert Einstein trips off every schoolchild's tongue and the famous photo of a straggly grey-haired scientist becomes one of the most instantly recognisable images in the world (Chapter 4 tells you about Einstein).

In early 20th-century science lessons, your instructors are likely to teach you about

- **Newton's equations of motion.** The mathematical formula $F = ma$ is vital, and you're expected to know all about equal and opposite reactions (or pretend that you do anyway).
- **Electricity and magnetism.** These two forces are all the rage in the early 20th century (and are still learned in school today). You can almost certainly quote Ohm's Law (the famous $V = IR$). You also probably know all about James Clerk Maxwell's realisation that electricity and magnetism are different aspects of the same thing (see Chapter 4 for more details about Maxwell).

If these topics don't sound too difficult to grasp, wait until a few years after the end of the First World War. Suddenly, the science syllabus expands, and students are introduced to what has become the most famous equation of all time – $E = mc^2$. (Parents of these pupils, who were steeped in Newton's laws of motion at school, are suddenly on dodgy ground when it comes to helping out with the homework!)

REMEMBER

The bottom line? Educating people about science changes all the time because science changes all the time.

For 200 years, everyone thought that Newton's views of the universe would never be bettered, and the vast majority of scientists believed that the equations he formulated described the universe in its entirety. But then along came Einstein with his crazy ideas about relativity as well as mass and energy being interchangeable. Everything changed. Yet this change wasn't an instantaneous process. Einstein published his special theory of relativity in 1905 but years passed before scientists widely accepted it.

Science works on consensus. A cherished view of how things in the universe are arranged may exist for years – even centuries – and then someone comes along and says, 'Aha. What about this?' Initially, the new idea may be dismissed, but as other scientists verify these new ideas, the consensus can change. That's why Einstein's theories are now believed to better describe the universe than Newton's.

Science is never a done deal. As you read this book, a scientist is sitting somewhere having a eureka moment, perhaps realising that Einstein's theories don't explain everything. Perhaps he or she is even beginning to realise the current theories about the origins of the universe, as described in this book, need refining. That scientist may have trouble convincing the thousands of scientists and students who do believe completely in Einstein. However, if the new theory has merit, a new consensus forms. When it does, the schoolchildren of tomorrow are going to be studying something different. And you may end up being the parent having difficulty comprehending *their* homework.

Contrasting Science and Religion

Science is one thing – religion is certainly another.

In most societies, kids are presented with religious ideas. In some cases religious and scientific ideas are in direct opposition, and in other cases they're not.

- Some people come to accept a religious viewpoint and discard any scientific notions that contradict it.
- Others come to the conclusion that science offers the most believable answers and discard any religious notions.
- Many go along in life juggling the two – accepting ideas like the rise and fall of the dinosaurs millions of years ago, while believing that God (or a god) created the world.

Growing children – not to mention inquisitive adults – often have difficulty knowing which is right: science or religion.

In many critical ways, people who preach science and people who preach religion are similar. Both ask their adherents to make spectacular leaps of faith. Christians are asked to believe that Jesus performed miracles, whereas those steeped in science are challenged with the idea that the Earth rotates around the Sun rather than the seemingly obvious opposite. Both preachers and scientists argue that proof exists of their own views of the world.

At this point, you may be thinking, 'Hey, hang on a minute. Have I picked up *Religion For Dummies* or *Philosophy For Dummies* by mistake?' A quick check of the front cover reveals not, but we can't talk about the origins of the universe without at least a nod to the fields of religion and philosophy.

Drop into any university hall of residence after midnight, follow the smells of the strong coffee, and you soon find yourself immersed in just such discussions. If one immutable law of the universe exists, it's not that everything is affected by gravity or that energy isn't created or destroyed – it's that undergraduates in higher education ponder on how it all began, just as they did in a smaller way when they were 3 years old.

In this book we try to answer some of these tough questions. (Unfortunately, the scientists' answer in many cases is that we still don't really know.) However, we didn't write these chapters just for philosophising undergraduates. We're writing to appeal to anyone who has ever wondered where everything came from.

Defining Cosmology

Cosmology is the study of the development of the universe – small word; big topic! It tries to answer questions about how the universe came to be the way it is now, and where it's heading.

The big challenge with cosmology and the related science of astronomy – the study of all the stuff out in space – is that they are unlike most other sciences. In chemistry, for example, you can add one chemical to another in test tubes that you hold in your hands. In biology, you can put a beetle under a microscope and start dissecting it there and then.

Cosmology and astronomy are different. Humanity has only ever ventured as far as the Moon – a distance of a quarter of a million miles. Although that sounds like a long way, it's nothing to the scale of the universe. The Earth's nearest star, the Sun, is 150 million kilometres away – 360 times farther than humans have ever ventured. How can humans ever hope to understand the universe if they've explored so little of it? The answer is in the science of cosmology.

TECHNICAL STUFF

The word *cosmology* comes from Greek roots – *kósmos,* meaning world or universe and *logos,* meaning word or study. Yet the word wasn't coined until long after the ancient Greeks lost their power. The term was probably first used some time in the 18th century when natural philosophers (as some scientists were then called) starting looking at Newton's work and realised that it changed humans' entire view of the universe.

Cosmology and astronomy are very closely related, but whereas astronomers study everything within the universe (stars, galaxies, and so on), cosmologists study the universe and its evolution as a whole. As a result, cosmologists need to know about astronomy as well as physics – both the traditional and the odder kinds of physics, such as quantum mechanics.

So how do you become a cosmologist? Just thinking about the origins of the universe makes everyone into an amateur cosmologist. And the purpose of this book is to help answer some of these tough questions.

If it's been a while since you thought about science, you may want to take a look at the Appendix, which outlines the special ways scientists use to describe numbers and the units of measurement that are sometimes hard to comprehend.

Seeing the beginning of the universe

Knowing how the universe began can be very helpful in understanding why the universe is the way is.

So how can cosmologists see the beginning of the universe? The short answer is that they can't – not directly at least. Sorry. If you were expecting a simple, definitive answer – like Douglas Adams' assertion in *The Hitchhiker's Guide to the Galaxy* that the answer to all the questions of the universe is 42 – you're going to be disappointed with cosmology.

But that is not to say there is no way to find out about the universe's past. That's because, as Einstein showed, 'time' isn't as straightforward as the clock on your wall suggests. This strangeness actually helps with the study of cosmology.

For example, when you look around at the night sky, you're actually looking at the universe at different stages of its development. When you observe a galaxy so far away that its light is 12 billion years old, you're essentially seeing a galaxy that was one of the earliest ever created. If cosmologists can figure out how this early galaxy was formed, they know something about how the universe was immediately before the formation. By taking similar small steps backwards, scientists can get closer and closer to the universe's starting point. See the sidebar 'When is now?' for more mind-blowing information about the nature of time.

QUIRKY COSMOS

When is now?

One of the big problems of cosmology is how to define *now.* Now is a very subjective idea.

Imagine your friend is standing at the other side of a large field holding a big red balloon. You have agreed with her that when *now* arrives, at the point when the time reaches midday, she pops the balloon.

Do you define the moment of now as

- The point when your synchronised watch shows midday?
- The point when you see your friend burst the balloon?
- The point when you hear the balloon pop?

Your friend insists that all three of these things happen at the same moment, yet your senses tell you that midday strikes, a tiny fraction of a second later you see the balloon burst, and then a couple of seconds later you hear the pop.

The same is true of the universe. When scientists observe the heavens, they're just seeing an Earth-bound version of now. If someone was to burst that balloon on the surface of a planet circling the nearby (in galactic terms) star of Proxima Centauri and you could observe the balloon's burst with a telescope, the light from Proxima Centauri would take more than four years to reach the Earth.

Furthermore, the most distant galaxies in the universe set off their light some 12 billion years ago. In the intervening time, one or more of these faraway galaxies may have exploded. Aliens living on a planet in one of these distant galaxies would certainly disagree with an Earth-based definition of now.

Dealing with the stretch limousine effect

On its own, looking farther away into space in order to see the past isn't enough to understand the origins of the universe. Even with more and more powerful telescopes that enable cosmologists to see farther and farther back in time, scientists reach a point beyond which they can never see.

At some point long ago, the universe wasn't composed of chemical elements such as hydrogen and helium gases, as it is today. Instead, the universe was made of smaller things – individual particles, such as electrons, protons, and neutrons. (Check out Chapter 9 for more on these.) In the early days these particles floated around freely, emitting and absorbing radiation.

This era, which scientists now believe ended some 380,000 years after the beginning of the universe, acts like the smoked windows on a stretch limousine. No matter how powerful the telescopes humans invent, scientists can never see through this smoked window.

This apparent barrier hasn't stopped scientists trying. In fact, cosmologists have detected a faint glow coming through this smoked window, known as the *cosmic microwave background* (see Chapter 6). By studying this glow, which over the years has cooled down to a point a few degrees above absolute zero, cosmologists hope to get a glimpse of the party going on inside.

As anyone who has ever tried to peep through the windows of a stretch limo can tell you, working out who or what's inside is almost impossible. But what scientists have discovered so far about the glow behind the universe's limo is strong evidence that the universe began in something called the *Big Bang.* In Chapter 6 we examine this amazing process, in which an infinitesimally small point expanded into the universe you see today.

Starting from scratch

If humans can't see beyond the smoked glass to the Big Bang itself, what hope do cosmologists have of understanding the origins of the universe? Luckily, scientists have devised other ways to study the origins of the universe.

You may have heard or read about places like CERN in Geneva, Switzerland or Fermilab, near Chicago, Illinois – fascinating subterranean laboratories with machines and gadgets that are extremely expensive to run. These laboratories and others are providing an alternative to trying to see beyond the smoked glass. The rationale behind these expensive endeavors is as follows: If scientists can't see beyond the glass, why not try to recreate what the first moments of the universe must have been like?

What scientists have discovered so far through CERN, Fermilab, and other projects is that the earliest universe consisted of an awful lot of particles zooming around. Everything had an incredibly high energy or temperature. By smashing together things like electrons and protons (two of the elementary building blocks of the universe) in machines called *particle accelerators* and watching what happens, scientists are replicating the earliest universe.

Based on their work, scientists believe that something very strange was going on back then. After a collision between two cars, you always end up with two cars, perhaps in a state of disrepair but recognisably automotive in nature. However, when elementary particles smash together, you don't have the same things afterwards. You may start off with two protons, but you can end up with a huge spray of other exotic particles that are created out of the energy of the collision.

Einstein's work (see Chapter 4) is essential to understand this seeming inconsistency. Specifically, Einstein's realisation that energy and mass are interchangeable helps explain how elementary particles can change into more exotic particles when smashed together. Scientists at places like CERN and Fermilab are looking at these exotic particles and figuring out what happened beyond that smoked glass.

Cosmology isn't just for scientists with access to the most powerful (and most expensive) telescopes and particle accelerators. Anyone interested enough can still make a splash. For example, three secondary students at the North Carolina School for Science and Mathematics examined public data from NASA's Chandra X-ray Observatory spacecraft and used it to discover the existence of a pulsar, a rapidly rotating star that gives off a distinctive signal. Who knows, maybe this book is your first step to discovering something new or explaining the unexplainable?!

Realising Why Now Is So Exciting

Even though scientists may have decided that 'now' is an outdated concept, the times you live in are very exciting for both amateur and professional cosmologists. Modern cosmology is in its infancy:

- A little more than a century ago, Einstein came up with his cosmos-shattering insights.
- A bit more than 80 years ago, astronomer Edwin Hubble (who we talk about in Chapter 5) showed that other galaxies besides the Milky Way existed. And if that weren't enough, Hubble also showed that the universe is expanding, which provides strong evidence that the universe began with a Big Bang.
- In the middle decades of the 20th century, *particle physics* – the physics of the tiniest particles that make up the stuff in the universe – came into being. As we discuss in Part III, understanding how these smallest pieces of matter function and interact tells scientists much about the origins of the universe.
- In the last two decades, dedicated cosmology experiments – like the COBE and WMAP space missions – started to spring up. Scientists are still trying to work out exactly what the results from these satellites mean in the grand scheme of things.

Over the next few decades, scientists are certain to find out more about the universe you live in and where it came from. Human curiosity will ensure that this happens.

If you're willing to share that curiosity, join us now for a rollercoaster ride through the cosmos.