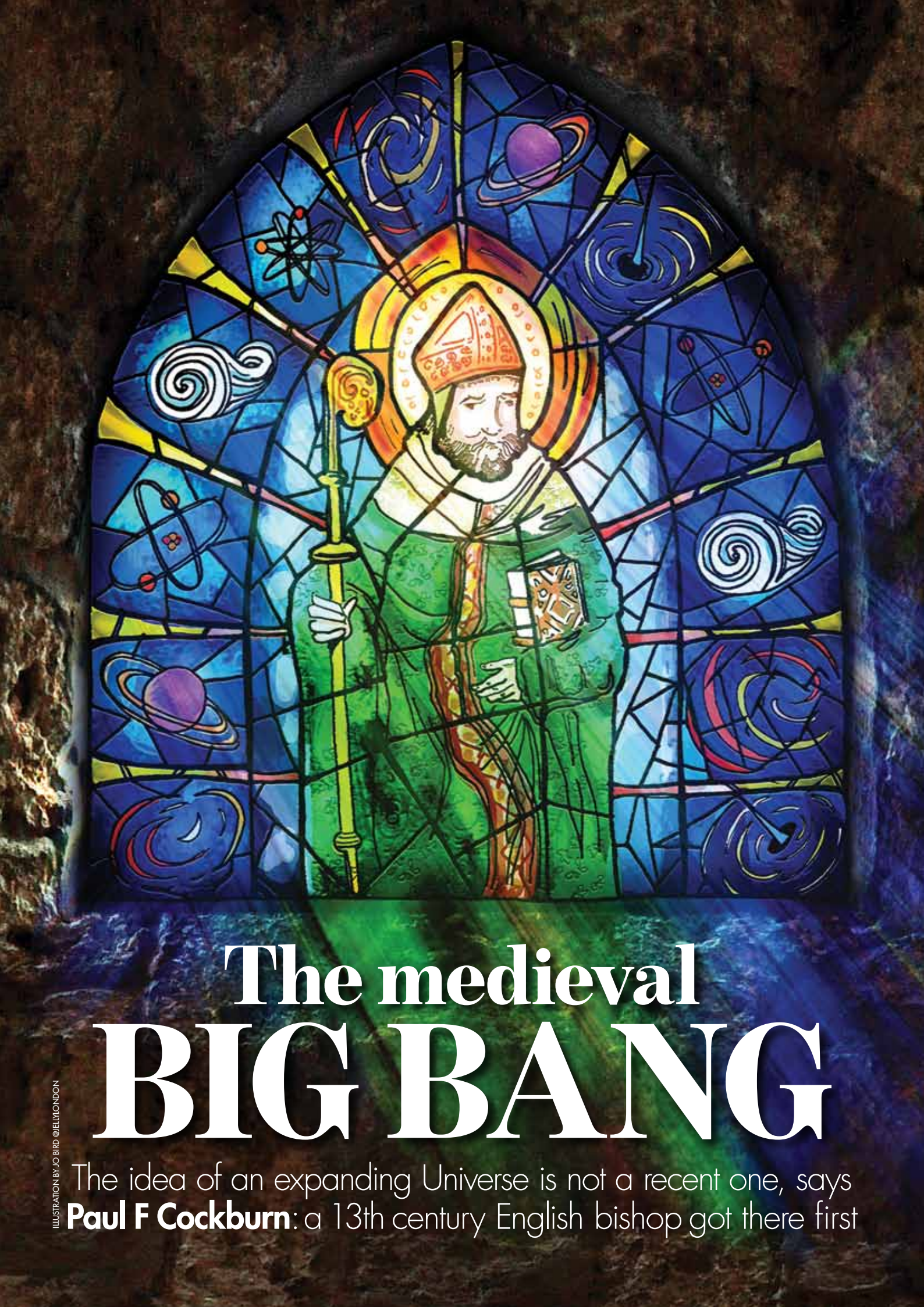


The medieval BIG BANG

The idea of an expanding Universe is not a recent one, says **Paul F Cockburn**: a 13th century English bishop got there first

ILLUSTRATION BY JO BIRD @JELLYONDON

▲ The University Church of St Mary has been associated with the University of Oxford since the 1200s; Grosseteste is likely to have taught here

One's a lump of rock between the orbits of Mars and Jupiter, previously known to interested astronomers as Minor Planet 36169. The other is a 13th-century English bishop, for centuries remembered – if at all – for his theological writings and possible influence on Simon de Montfort, a progenitor of modern parliamentary democracy. How would the latter, Robert Grosseteste, Bishop of Lincoln from 1235 to 1253, have reacted to last year's decision by the International Astronomical Union to name the former after him? It is certainly apt, given that he is known now for his contemplation and study of the cosmos.

Grosseteste (c1170-1253) built a solid academic and Church career (the two being pretty synonymous in 13th century England), and for many years lectured at the University of Oxford, where he also ran a Franciscan school. His interests were wide, however; according to Dr Giles Gasper, associate director of the Institute of Medieval and Renaissance Studies (IMRS – about to be renamed the Institute of Medieval and Early Modern Studies) at Durham University, "He was an absolute polymath."

By the standards of the day, Grosseteste was certainly an avid participant in European intellectual life, producing texts on the liberal arts, astronomy and cosmology, in addition to his main corpus of theological works. He was, for example, among the first Western thinkers to argue that natural phenomena could be described mathematically and he certainly helped to establish the scientific method.

Although largely overlooked at the time, Grosseteste's most remarked upon scientific work today is undoubtedly his succinct (by contemporary standards) treatise *De luce*, or 'Concerning Light'. In it, he proposed a model of the cosmos – created through expansion and which has changed through time – that is some 700 years ahead of the work of Georges Lemaître and Edwin Hubble, the fathers of modern day cosmology.

Admittedly, Grosseteste worked hard to accommodate the still-prevalent Aristotelian model of the Universe – which placed a static Earth at its centre, orbited by the Sun, Moon, other planets and stars – along with the Platonic idea of an unchanging, eternal Universe. "He had commented on Aristotle's *Physics* and theory on analytics, where the method of science is explained," says Dr Cecilia Panti, an acknowledged expert on *De luce* from the University of Rome. "So, Grosseteste applied some Aristotelian principles in his own works on natural philosophy."

Developing medieval ideas

Grosseteste's solution was to suggest an expanding but finite Universe of lux (light) carrying matter away from a central point. The Universe eventually reaches a point of stasis where another form of light, lumen, encourages it to begin contracting again until it reaches a point of minimum density, which is where the first sphere or firmament in Grosseteste's model crystalises (or 'actualises'). This process repeats until the centre of the Universe is reached, creating the familiar nine celestial spheres carrying the stars and planets around Earth.

It may sound bizarre, but academics from the UK, Italy and Canada are currently working together to develop fresh appreciations of medieval scientific thought. As part of Durham University's Ordered Universe Project, members of its Institute of Computational Cosmology (ICC) – one of the world's leading centres for research into the origin and evolution of the Universe – have teamed up with IMRS to model Grosseteste's description of the Universe, to see if it could possibly work as predicted.

> "Academics are currently developing fresh appreciations of medieval scientific thought"

INSTITUTE OF COMPUTATIONAL COSMOLOGY X 3, THINKSTOCK

◄ Aristotle's model of the Universe, consisting of concentric celestial spheres, was accepted as the way the cosmos was organised in the Middle Ages, as shown here in the *Nuremburg Chronicle* of 1493

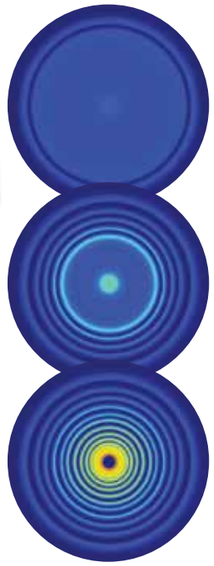
"The bit that we found hardest to understand was the creation of the celestial spheres," admits Prof Richard Bower, who is part of the ICC. "We didn't understand why Grosseteste thought they would be created, with distinct properties, at different times. Eventually we realised the key was the ratio of the amount of matter to the amount of lumen that's required for this 'actualisation', so we took that and programmed it into the computer."

So with equations describing the distribution and flow of matter, and how lux and lumen interacted with it, the ICC team discovered that they could create a model that worked as Grosseteste suggested. "You get the creation of an outer sphere, then an additional inner sphere, and then one inward of that and so on, the spacing of the spheres getting smaller and smaller, much like the drawings you see from the time," says Bower. "It's beautiful, and you go: OK, I begin to see why people weren't completely crazy believing in this."

Hallmarks of modern science

"Accepting that view of the Universe, this provides a really modern way of explaining how it got into the state that it's in," Bower adds. "One of the striking things is that – if you can buy into the view people had – you'd have been quite happy with the explanation. It has a lot of the hallmarks of doing modern science and trying to explain the Universe as we do it today."

Prof Tom McLeish, pro-vice-chancellor (research) at Durham University, who instigated the project, agrees. "Robert Grosseteste set himself the same questions that cosmologists today are setting themselves: what is out there and how did it get to be? He comes to different conclusions. We would say today that he wasn't right, but in a sense that's far less important than the methods." ▸



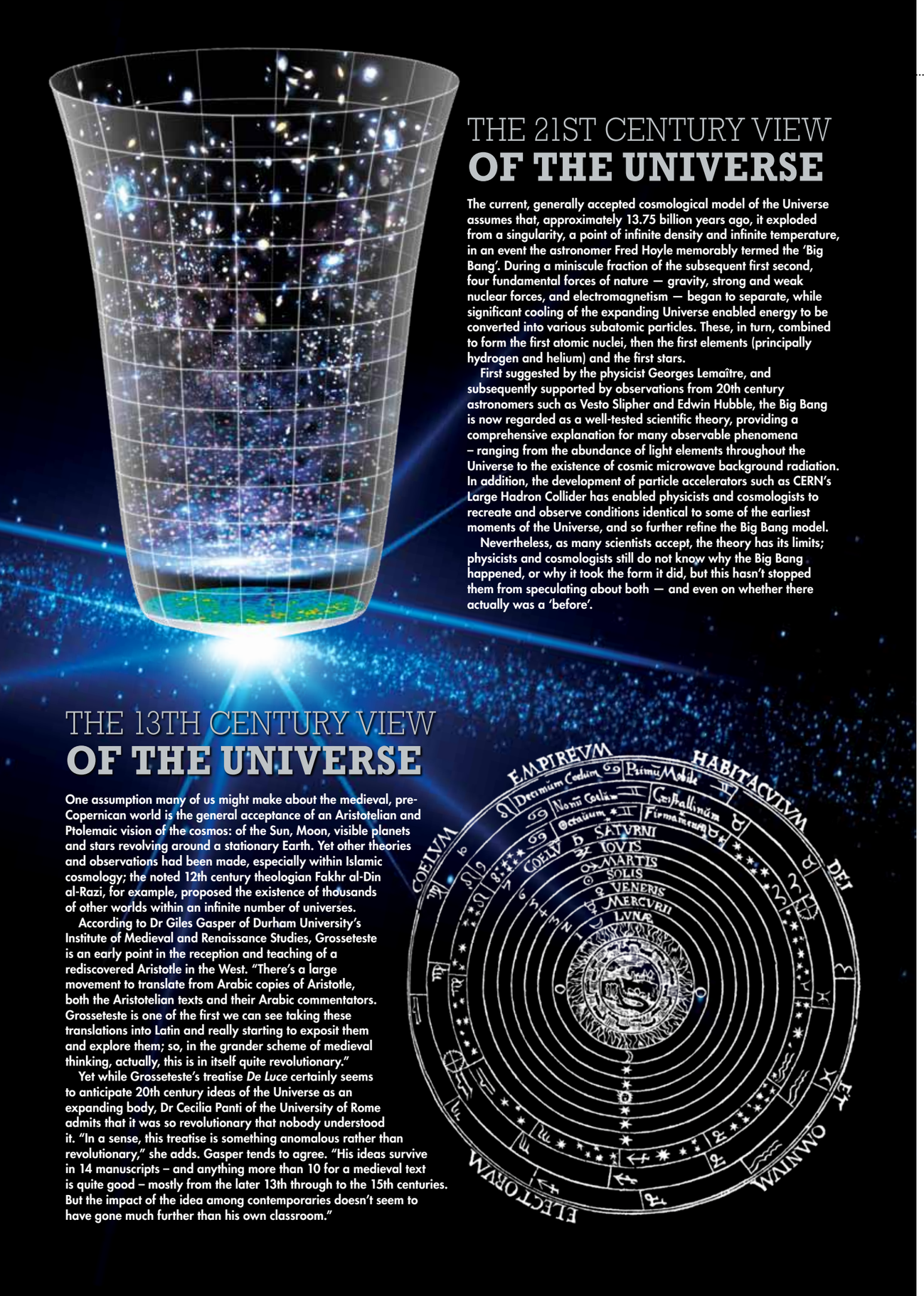
◄ Stills from the ICC's simulation of Grosseteste's universe show the shells developing over time, much as the bishop himself imagined

Robert Grosseteste
PRE-RENAISSANCE MAN

Relatively little is known about the early life and education of Suffolk-born Robert Grosseteste, but it's generally agreed that this English theologian and philosopher became a major figure in the English church during the 13th century.

Although admired and respected as a teacher and theologian in Oxford during the early 1230s, Grosseteste was nevertheless a compromise candidate for the post of Bishop of Lincoln — the largest diocese in England at the time. However, he would prove to be very much his own man during his 18 years in the post, willing to criticise not just parts of his own diocese, but also the wider church. His last letter to the papal notory, outlining theological and canonical reasons for opposing the appointment of a non-English speaking cleric in his diocese, was viewed by many 16th century thinkers as proof Grosseteste was a proto-Protestant, although later historians have since rejected this view.

It was Grosseteste's earlier writings, specifically a series of scientific treatises written before 1235 – covering astronomy, cosmogony, mathematics and the natural world – that inspired historian Alastair Crombie to describe him as "the real founder of the tradition of scientific thought in medieval Oxford and, in some ways, of the modern English intellectual tradition" in 1953. According to Dr Cecilia Panti of the University of Rome, later historians have largely refuted this claim, but "what remains of this view is the interest of Grosseteste in scientific problems: what a rainbow is, what light is, what is body, what is sound? And he answers in a specific way by using Aristotelian principles, also recognising the importance of experience."



THE 21ST CENTURY VIEW
OF THE UNIVERSE

The current, generally accepted cosmological model of the Universe assumes that, approximately 13.75 billion years ago, it exploded from a singularity, a point of infinite density and infinite temperature, in an event the astronomer Fred Hoyle memorably termed the 'Big Bang'. During a miniscule fraction of the subsequent first second, four fundamental forces of nature — gravity, strong and weak nuclear forces, and electromagnetism — began to separate, while significant cooling of the expanding Universe enabled energy to be converted into various subatomic particles. These, in turn, combined to form the first atomic nuclei, then the first elements (principally hydrogen and helium) and the first stars.

First suggested by the physicist Georges Lemaître, and subsequently supported by observations from 20th century astronomers such as Vesto Slipher and Edwin Hubble, the Big Bang is now regarded as a well-tested scientific theory, providing a comprehensive explanation for many observable phenomena – ranging from the abundance of light elements throughout the Universe to the existence of cosmic microwave background radiation. In addition, the development of particle accelerators such as CERN's Large Hadron Collider has enabled physicists and cosmologists to recreate and observe conditions identical to some of the earliest moments of the Universe, and so further refine the Big Bang model.

Nevertheless, as many scientists accept, the theory has its limits; physicists and cosmologists still do not know why the Big Bang happened, or why it took the form it did, but this hasn't stopped them from speculating about both — and even on whether there actually was a 'before'.

THE 13TH CENTURY VIEW
OF THE UNIVERSE

One assumption many of us might make about the medieval, pre-Copernican world is the general acceptance of an Aristotelian and Ptolemaic vision of the cosmos: of the Sun, Moon, visible planets and stars revolving around a stationary Earth. Yet other theories and observations had been made, especially within Islamic cosmology; the noted 12th century theologian Fakhr al-Din al-Razi, for example, proposed the existence of thousands of other worlds within an infinite number of universes.

According to Dr Giles Gasper of Durham University's Institute of Medieval and Renaissance Studies, Grosseteste is an early point in the reception and teaching of a rediscovered Aristotle in the West. "There's a large movement to translate from Arabic copies of Aristotle, both the Aristotelian texts and their Arabic commentators. Grosseteste is one of the first we can see taking these translations into Latin and really starting to exposit them and explore them; so, in the grander scheme of medieval thinking, actually, this is in itself quite revolutionary."

Yet while Grosseteste's treatise *De Luce* certainly seems to anticipate 20th century ideas of the Universe as an expanding body, Dr Cecilia Panti of the University of Rome admits that it was so revolutionary that nobody understood it. "In a sense, this treatise is something anomalous rather than revolutionary," she adds. Gasper tends to agree. "His ideas survive in 14 manuscripts – and anything more than 10 for a medieval text is quite good – mostly from the later 13th through to the 15th centuries. But the impact of the idea among contemporaries doesn't seem to have gone much further than his own classroom."

► According to Panti, the introduction of Aristotle's *Physics* to the West created a new idea of what science is. "Aristotle introduced the idea of physics being an autonomous science; Grosseteste grasped this concept, which is why he was so interested in nature," she says. "He was sure that by looking at nature you can gain a scientific knowledge of what nature is – which, for that time, was something pretty new."

The fact that he was wrong is almost incidental, McLeish explains. "The way he was thinking and calculating was extraordinary," he says. "He was working with a cosmology from the ancients but, unlike the ancients who just stopped at the question 'What is out there?', Grosseteste went on to the second question: 'How did it get there?' The fact he did that was a big step forward and the way he did it was an even bigger step forward. He described a physical theory; he was using physics to try and outline a cosmogony, a theory of how the Universe got to be."

Cosmogony progeny

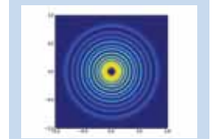
Making that theory work was certainly a challenge for the ICC team, who are more familiar with generating highly complex computer models of the Universe that, by comparing them with actual astronomical observations, have helped physicists fine-tune their theories about the cosmos.

"Normally the way we'd work is that we'd have some basic equations that describe how the Universe behaves – Newton's laws, Einstein's general theory of relativity – and we'd have some idea of how the Universe began," says Bower. "We programme the laws of physics into the computer, the initial conditions, and we basically let it go and see how it predicts what the Universe would look like today. Grosseteste had a very different view of how these things work, but it's interesting to take the way we work in modern cosmology and apply it to the ideas that were kicking around in the 13th century."

▲ The ICC team used the powerful COSMA-5 computer to expand on cosmological concepts from the medieval era

ON THE CD

Watch a simulation of Grosseteste's universe and its shells



At the time, *De luce* proved to be more anomalous than revolutionary, remaining largely overlooked until the 20th century when the concept of the Big Bang gave Grosseteste's work new significance. Ironically enough, that would be in part thanks to another man who showed how religion and science – or at least physics – need not be incompatible.

In 1927, Georges Lemaître, a priest and professor of physics at the Catholic University of Leuven, proposed the main foundations of an expanding Universe model, including his 'hypothesis of the primeval atom'. However, like Grosseteste's theory, there was a lack of supporting data; that would come two years later, at the Mount Wilson Observatory in California, when Edwin Hubble showed that galaxies were indeed moving away at high speeds. S

ABOUT THE WRITER

Paul F Cockburn is an Edinburgh-based journalist who specialises in popular science; his favourite course while studying at the University of Edinburgh was – naturally – history of science.

THE **EXPERT**

Prof Richard Bower of the Institute of Computational Cosmology (ICC) at Durham University on modelling Robert Grosseteste's universe

How did modelling Grosseteste's universe differ from your normal work?
Nothing is described in mathematical language, so you have to read his words and try to understand what he's getting at, and then come up with some set of equations that you think describes what he was trying to express in words. We had long, extensive arguments about what he really meant; once we agreed the equations to use, then you can program them into the computer and calculate what his Universe should look like. What's really fascinating is that we get something that looks very much like the way people thought the Universe was at that time.

What have you learned from the project?
I begin to see why people in medieval times believed this. It has its own logic, its own sense; it has this extra spiritual dimension, which is quite alien to the way we do science today, but it explains so much about the world. Of course, one of the things wrong with Grosseteste's idea was that Earth was stationary, but the accepted opinion at the time was that Earth was still; hence this was why you'd construct the Universe in this particular way. You could worry that in modern cosmology we make a similar kind of mistake, that we construct our Universe with dark matter and dark energy. Although this model describes things well, will a future generation look back and think: "Didn't they realise that it all makes much more sense if they only did this?" So, it gives your work a sense of perspective; you see that you're just a step in the development of understanding the world.