

Chapter 5

THE PARADIGM SHIFT

You see, wire telegraph is a kind of a very, very long cat. You pull his tail in New York and his head is meowing in Los Angeles. Do you understand this? And radio operates exactly the same way: you send signals here, they receive them there. The only difference is that there is no cat.

ALBERT EINSTEIN

The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it) but 'That's funny . . .'

ISAAC ASIMOV

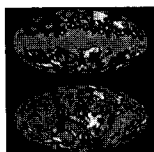
In general we look for a new law by the following process. First you guess. Don't laugh, this is the most important step. Then you compute the consequences. Compare the consequences to experience. If it disagrees with experience, the guess is wrong. In that simple statement is the key to science. It doesn't matter how beautiful your guess is or how smart you are or what your name is. If it disagrees with experience, it's wrong. That's all there is to it.

RICHARD FEYNMAN



Hypothesis

1911



There were now two dominant theories fighting for control of the universe. In one corner was the Big Bang model, which had evolved out of Einstein's theory of general relativity, thanks to Lemaître and Friedmann. It proposed a unique moment of creation followed by a rapid expansion, and sure enough Hubble had observed that the universe was expanding and the galaxies were receding. Also, Gamow and Alpher had shown that the Big Bang could explain the abundances of hydrogen and helium. In the other corner was the Steady State model, invented by Hoyle, Gold and Bondi, which harked back to the conservative view of an eternal universe, except that it included an element of continuous creation and expansion. This creation and expansion made the model compatible with all the astronomical observations, including Hubble's observed redshifts from the receding galaxies.

Scientific debates over the strengths of competing theories usually take place in university coffee-rooms or at the elite conferences where great minds convene. However, when it came to the question of whether the universe was eternal or created – the ultimate cosmological question – the discussion spilled over into the public arena, partly encouraged by the various popular books and radio broadcasts by Hoyle, Gamow and other cosmologists.

Pope endorses BB

Not surprisingly, the Catholic Church was keen to make known its view on the cosmological debate. Pope Pius XII, who had already proclaimed that evolutionary biology was not in conflict with the Church's teaching, appeared at the Pontifical Academy of Sciences on 22 November 1951 to deliver an address entitled 'The Proofs for the Existence of God in the Light of Modern Natural Science'. In particular, the Pope strongly endorsed the Big Bang model, which he perceived as a scientific interpretation of Genesis and evidence for the existence of God:

Thus everything seems to indicate that the material universe had a mighty beginning in time, endowed as it was with vast reserves of energy, in virtue of which, at first rapidly and then ever more slowly, it evolved into its present state . . . In fact, it would seem that present-day science, with one sweeping step back across millions of centuries, has succeeded in bearing witness to that primordial *Fiat lux* uttered at the moment when, along with matter, there burst forth from nothing a sea of light and radiation, while the particles of chemical elements split and formed into millions of galaxies . . . Therefore, there is a Creator. Therefore, God exists! Although it is neither explicit nor complete, this is the reply we were awaiting from science, and which the present human generation is awaiting from it.

The Pope's address, which also included a specific mention of Hubble and his observations, made headlines in newspapers around the world. One of Hubble's friends, Elmer Davis, read the address and could not resist writing to Hubble and joking: 'I am used to seeing you earn new and ever higher distinctions; but till I read this morning's paper I had not dreamed that the Pope would have to fall back on you for proof of the existence of God. This ought to qualify you, in due course, for sainthood.'

Surprisingly, the atheist George Gamow enjoyed the Papal

attention given to his field of research. He wrote to Pius XII after the address, sending him a popular article on cosmology and a copy of his book *The Creation of the Universe*. He even went as far as mischievously quoting the Pope in a research paper he published in 1952 in the prestigious journal *Physical Review*, knowing full well that this would annoy many of his colleagues, who were anxious to avoid any overlap between science and religion. Garrison

The overwhelming majority of scientists felt strongly that deciding the validity of the Big Bang model had nothing whatsoever to do with the Pope and that his endorsement should not be used in any serious scientific debate. In fact, it was not long before the Papal endorsement backfired and became an embarrassment for the Big Bang proponents. Supporters of the rival Steady State model began to use the Papal address as a way of mocking the Big Bang. The British physicist William Bonner, for example, suggested that the Big Bang theory was part of a conspiracy aimed at shoring up Christianity: 'The underlying motive is, of course, to bring in God as creator. It seems like the opportunity Christian theology has been waiting for ever since science began to depose religion from the minds of rational men in the seventeenth century.'

Fred Hoyle was equally scathing when it came to the Big Bang's association with religion, condemning it as a model built on Judeo-Christian foundations. His views were shared by his Steady State collaborator, Thomas Gold. When Gold heard that Pius XII had backed the Big Bang, his response was short and to the point: 'Well, the Pope also endorsed the stationary Earth.'

Scientists had been wary of the Vatican's attempts to influence the course of science ever since Urban VIII had forced Galileo to recant in 1633. However, this wariness sometimes bordered on paranoia, as noted by the English Nobel Laureate George Thomson: 'Probably every physicist would believe in a creation if

Lemaître asks Pope to keep quiet

the Bible had not unfortunately said something about it many years ago and made it seem old-fashioned.'

Perhaps the most important voice in the debate over the role of theology in cosmology was Monsignor Georges Lemaître, co-inventor of the Big Bang model and a member of the Pontifical Academy of Sciences. It was Lemaître's firm belief that scientific endeavour should stand isolated from the religious realm. With specific regard to his Big Bang theory, he commented: 'As far as I can see, such a theory remains entirely outside any metaphysical or religious question.' Lemaître had always been careful to keep his parallel careers in cosmology and theology on separate tracks, in the belief that one led him to a clearer comprehension of the material world, while the other led to a greater understanding of the spiritual realm: 'To search thoroughly for the truth involves a searching of souls as well as of spectra.' Not surprisingly, he was frustrated and annoyed by the Pope's deliberate mixing of theology and cosmology. One student who saw Lemaître upon his return from hearing the Pope's address to the Academy recalled him 'storming into class . . . his usual jocularly entirely missing'.

Lemaître was determined to discourage the Pope from making proclamations about cosmology, partly to halt the embarrassment that was being caused to supporters of the Big Bang, but also to avoid any potential difficulties for the Church. If the Pope – caught up as he was by his enthusiasm for the Big Bang model – were to endorse the scientific method and utilise it to support the Catholic Church, then this policy might rebound if new scientific discoveries contradicted Biblical teachings. Lemaître contacted Daniel O'Connell, director of the Vatican Observatory and the Pope's science advisor, and suggested that together they try to persuade the Pope to keep quiet on cosmology. The Pope was surprisingly compliant and agreed to the request – the Big Bang would no longer be a matter suitable for Papal addresses.

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beginning of the universe. They call it "The Big Bang". Isn't it weird how scientists can imagine all the matter of the universe exploding out of a dot smaller than the head of a pin, but they can't come up with a more evocative name for it than "The Big Bang"? That's the whole problem with science. You've got a bunch of empiricists trying to describe things of unimaginable wonder.' Calvin goes on to suggest 'The Horrendous Space Kabloolie!' as an alternative title, which some cosmologists actually used for a while, sometimes abbreviating it to the HSK.

The following year, *Sky & Telescope* magazine ran a competition to replace the Big Bang label, but the esteemed panel of judges, Carl Sagan, Hugh Downs and Timothy Ferris, were not impressed by the entries. Suggestions for new titles included 'Hubble Bubble', 'Bertha D. Universe' and 'SAGAN' ('Scientists Awestruck by God's Awesome Nature'). They concluded that none of the 13,099 suggestions from forty-one countries was any better than Hoyle's original derisive 'Big Bang' tag.

It seems as though this is a testament to the fact that the Big Bang model is now part of our culture. An entire generation has grown up with the Big Bang as the model that explains the creation, evolution and history of the universe, and we could not imagine this theory by any other name.

Even the Church has grown to love the Big Bang model. Ever since Pope Pius XII endorsed the Big Bang, the Catholic Church has largely tolerated this scientific view of creation. It has effectively abandoned any pretence that Scripture gives a literal explanation for the universe. This has proved to be a very pragmatic change of attitude. In the past, God provided the guiding hand behind all the mysteries of the universe, from volcanic eruptions to the setting of the Sun, but one by one science has provided rational and natural explanations for these phenomena. The chemist Charles Coulson coined the term 'God of the gaps' to point out that a deity who was

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supposedly responsible for everything beyond our comprehension would have his power diminished as each gap in knowledge was filled by science. But now the Catholic Church concentrates on the spiritual world and leaves the job of explaining the natural world to science, which means that it can remain secure in the knowledge that any future scientific discoveries cannot diminish the status of God. Science and religion can live independently, side by side.

In 1988, as if to reinforce this independence, Pope John Paul II declared: 'Christianity possesses the source of its justification within itself and does not expect science to constitute its primary apologetic.' Then, in 1992, the Vatican even admitted that it had been wrong to persecute Galileo. Advocating a Sun-centred view of the universe had been considered heresy because, according to the Bible: 'God fixed the Earth upon its foundation, not to be moved for ever.' However, after an inquiry that lasted thirteen years, Cardinal Paul Poupard reported that theologians at the time of Galileo's trial 'failed to grasp the profound non-literal meaning of the Scriptures when they describe the physical structure of the universe'. And in 1999 the Pope symbolically put an end to the centuries-old conflict between religion and cosmology when he toured his Polish homeland and visited the birthplace of Nicholas Copernicus, specifically praising Copernicus's scientific achievements.

Perhaps encouraged by the Church's newfound tolerance, some cosmologists have decided to delve into the philosophical implications of the Big Bang model. For example, the model describes how the universe started from a hot, dense, primordial soup and then evolved into the vast array of galaxies, stars, planets and life forms that exist today – was this inevitable, or could the universe have been different? The Astronomer Royal, Martin Rees, addresses this issue in his book *Just Six Numbers*. In it he explains how the structure of the universe ultimately depends on just six parameters, such as the strength of gravity. Scientists can measure the value of