Before the Big Bang

Georges Lemaître, PhD '27, laid the groundwork for the theory while studying at MIT.

By MARCIA BARTUSIAK

The idea that the universe is expanding was one of the most revolutionary and unsettling findings of modern astronomy. But the discovery was not made by Edwin Hubble at the Mount Wilson Observatory in California in 1929, as so many textbooks suggest. The germ of the idea actually arose in the halls of MIT and Harvard, a few years before Hubble initiated his historic measurements of galaxy motions. It hatched in the mind of a Jesuit priest then studying at the Institute's physics department.

A military hero, Georges Lemaître had received the Croix de Guerre for his service in the Belgian artillery after Germany invaded his homeland in World War I. He went on to earn a doctorate in mathematics at the Catholic University of Louvain; afterward, perhaps affected by the horrors he observed from the trenches, he enrolled in a seminary. Although he was ordained in 1923, the Church permitted him to continue his scientific pursuits. Captivated by the beauty of Einstein's new general theory of relativity, the abbé proceeded to the University of Cambridge to broaden his understanding of the theory's equations under the guidance of the astrophysicist Arthur Eddington, who deemed his student "exceptionally brilliant."

In 1924, after a year in England, Lemaître traveled to the United States to study at Harvard's observatory and enroll in MIT's PhD program in physics. His dark hair combed straight back and his cherubic face adorned with round glasses, he could easily be spotted on the college campuses by his attire—a black suit or an ankle-length cassock, set off by a stiff white clerical collar. Some could find him just by following the sound of his full, loud laugh, which was readily aroused.

In pursuit of his second PhD, Lemaître became interested in applying general relativity to the universe at large, which many in the 1920s believed to consist entirely of our own galaxy. By then totally absorbed by astronomy, he made sure to attend the 1925 meeting of the American Astronomical Society in Washington, DC, where a crucial discovery was announced: Edwin Hubble had proved that certain spiral nebulae, previously thought to be gaseous clouds within the Milky Way, were actually separate galaxies far beyond its borders.

While others in the room were focused on Hubble's revelations about the true nature of these long-perplexing nebulae, Lemaître was two jumps ahead. Though new to astronomy, he quickly realized that the newfound galaxies could be used to test certain predictions that general relativity made about the universe's behavior. Soon after the meeting, Lemaître began formulating his own cosmological model.

Two models were already in circulation in the astrophysical community. According to the first, proposed by Einstein himself in 1917, the universe contained so much matter that space-time wrapped itself up into a hyperdimensional ball—a closed, stable, enduring system. The second, posited soon after by the Dutch astronomer Willem de Sitter, was very different: it assumed that cosmic densities were so low that the universe could be considered empty. The unique properties of space-time that arose in this model caused light waves to get longer the farther they traveled from their source. This aspect of the model was consistent with some recent astronomical news that de Sitter was well aware of, but Einstein wasn't.

At the Lowell Observatory in Arizona, astronomer Vesto Slipher was measuring the spectra of spiral nebulae—the unique patterns of colors emitted by the chemical elements within them. The majority of these emissions turned out to be redder—that is, longer in wavelength—than the colors emitted by the same elements on Earth. This shift could be explained if the nebulae were moving outward into space; think of the way the pitch of an ambulance siren gets lower as the vehicle speeds away. If so, Slipher was seeing the nebulae recede at up to 1,100 kilometers per second, the greatest celestial velocities that had ever been observed. But de Sitter posited that the nebulae might only appear to be moving, the light waves themselves getting longer and longer as the light traveled toward Earth.

Lemaître was not comfortable with either model. De Sitter's could explain the redshifted nebulae but required a universe that was empty (which he was sure it was not); Einstein's accommodated a universe filled with matter but couldn't account for the fleeing nebulae. Lemaître aimed, as he put it, to "combine the advantages of both."

While studying at MIT, Lemaître visited Slipher at the Lowell Observatory and Hubble at Mount Wilson to learn the latest velocity and distance measurements for what were now known to be

In 2004, those informal connections and some mentoring helped him land a job in Major League Baseball's labor-relations department, which negotiates and administers collective-bargaining agreements with players and umpires. There, he found himself drawing on quantitative skills he'd honed as a political-science major at MIT. "There were lots of public-policy-oriented problems that we looked at quantitatively," he says. "It's not altogether different from the stuff I did in the commissioner's office."

The group also served as a central advisor to MLB teams, giving Abbamondi a consulting opportunity that would prove a crucial stepping stone. "It was a good place to learn the business," he says. "Club executives would come to you with their trickier problems, and we got to respond and help clubs solve them. We got a ton of experience, and got to meet people from a lot of clubs." Shortly after the Cardinals' 2006 victory, John Mozeliak, then the club's assistant GM, asked for advice on contract negotiations with David Eckstein, who'd just received the World Series MVP award. "We could act as a dispassionate third party and say, 'He's a great player, but here's what this similar player signed for as a comparison,'" he says.

So when Mozeliak succeeded Walt Jocketty as general manager, he already knew what Abbamondi could do. Abbamondi joined the club in December 2007, and his network of relationships paid almost immediate dividends. "I'd only been there for a month or so when we traded Scott Rolen to the Toronto Blue Jays for Troy Glaus," he says. "Since I had helped the Blue Jays' assistant GM out in the past in my role at MLB, we already knew each other. I like to think I'd built a reputation as a straight shooter, so they knew that a guy who was helping them a month ago wasn't going to screw them now."

Being a straight shooter is a major asset in baseball. Although it may be a simple game (as the irascible coach in *Bull Durham* put it, "You throw the ball, you hit the ball, you catch the ball"), the work that goes into building a baseball team is anything but simple. While it used to be mainly a matter of conferring with scouts and drafting and assembling the best players you could afford, today's baseball executives must evaluate and integrate information from a flood of diverse sources–scouting reports, statistical analysis, medical data, and contract and payroll figures. "It's all about looking at all the information you can find and putting it together in a way that makes sense to help you make the best decisions," says Abbamondi. "How can we give ourselves the best possible chance of doing something nearly impossible: predicting the future?"

If a club is weighing whether to acquire a particular pitcher, for example, one of the first questions is whether he's likely to stay healthy. "Of course we'll lean heavily on medical-staff opinion, but we also want to know what our scouts think of his pitching mechanics," Abbamondi says. "Do they see any red flags that might lead to injury? Meanwhile, the stats guy may look at the track record of other pitchers who have thrown this many innings by this age." The trick is to blend qualitative and quantitative analysis.

"The foundation of all analysis tends to go back to scouting, but that's one guy sitting in a ballpark, and you can't have people at every game," he says. Statistical tools like Pitch F/x, which delivers data on every pitch thrown, can help confirm or refute the more subjective analysis. "Say a scout went to see a prospect and wrote a glowing report," says Abbamondi. "We can check that game data to see if it's consistent with this pitcher's other games. If the data shows us that the pitcher was doing something a little different that day, maybe the scout caught him on a very good day. We might not realize it was an outlier without that data."

Abbamondi has also helped lead an effort to make the club's information much more accessible–and easier to slice and dice. For example, scouts now submit player evaluation reports to a Web-based database that's integrated with the Cardinals' statistical systems. "Fifty years ago, if you wanted to know about a player, you pulled a written file," he says. But now, "I can go to one system and ask for all the left-handed relief pitchers with scouting grades above a certain level and statistical projections at or above a certain number."

Beyond making it easier to analyze the existing information, Abbamondi tries to build competitive advantage by adopting ideas from unlikely places. "You have to look outside our industry to think about how we can continually improve," he says, citing a chapter from surgeon and *New Yorker* medical writer Atul Gawande's book *Better* that explores the dramatic improvement in battlefield survival rates in the past decade. "It wasn't an advance in medical technology but, rather, process improvement in battlefield triage treatment," he says. "They are changing the supply chain in medical care, and we think about how that could translate to baseball. Should we wait for better MRI technology to predict pitcher injuries, or can we do it by improving processes or how we are organized?"

In a sense, baseball is a sport of numbers, but Abbamondi never forgets that those statistics are produced by humans. "Our business is different in that our units of productions are people with real-world problems, and [it's important to go] above and beyond baseball analysis to deal with those issues," he says. "We have a player, Khalil Greene, dealing with social-anxiety disorder. Knowing what he's going through and how it's affecting him and the team is the sort of thing you can't learn from a spreadsheet. You have to be around the clubhouse and get to know the players as people, and do what you can to put them in a place to succeed."

Because of baseball's human element, fans forge emotional connections that can last lifetimes and cross generations. Sitting in the dugout of Dodger Stadium last year, Abbamondi flashed back to his first baseball game, which he'd watched with his father at that very stadium. "I'm fortunate to work in a game where I can still touch on the memories from my childhood, and sometimes that comes home in a deep way," he says. "I still get a real sense of wonder getting to watch players like Pujols take batting practice every day, and I hope that never wears off." ■

NO WAY, ABBÉ In 1927, Albert Einstein dismissed Georges Lemaître's theory that the universe is expanding. By the time of this 1933 encounter, the Belgian priest had been vindicated.

RUE DES ARCHIVES/THE GRANGER COLLECTION

spiral galaxies. With this information in hand, he took a first stab at a new solution, but he had not fully developed it by the end of 1925, when he handed in his PhD thesis and left MIT. His thesis contained a preliminary model, a modification of de Sitter's view of the universe. On returning to Belgium, where he became a professor at the Catholic University of Louvain, he fleshed out that modification into an entirely new model, which he published in 1927. Nearly two full years before Hubble provided the definitive observational proof, Lemaître unveiled a cosmological model in which space-time continually stretches, and galaxies surf outward on the wave. Their retreat, he wrote in his paper, is "a cosmical effect of the expansion of the universe." He even estimated a rate of expansion close to the figure that Hubble eventually calculated.

This was a tremendous accomplishment and offered an astounding vision of how the universe operates. But no one noticed—no one at all. Lemaître's paper was completely ignored, probably because he inexplicably published it in an obscure Belgian journal. A similar solution, conceived independently in 1922 by the Russian mathematician Aleksandr Friedmann, went unnoticed as well. At a 1927 meeting in Brussels, the young priest cornered Einstein and tried to persuade him. But the world-renowned physicist replied, "Your calculations are correct, but your physical insight is abominable." Einstein refused to imagine a universe in which space-time was stretching.

The impasse stood for a couple of years. But in 1929, Hubble verified that the galaxies were moving outward in a uniform way, and Lemaître's paper, finally noticed by Eddington and consequently reprinted in 1931 in the more prominent *Monthly Notices of the Royal Astronomical Society*, explained why Hubble saw the velocities of the galaxies steadily increase with distance. Only then was the expanding universe truly recognized. Astronomers and theorists alike were thunderstruck by this radically new cosmic setup, breathtaking in its grandeur and terrifying in its implications.

Perhaps most consequential was the question that Lemaître first posed in his 1927 paper: How did this expansion get started? "It remains to find the cause," he wrote at the time. But within four years he boldly suggested in the journal *Nature* that all the mass-energy of the universe was once packed within a "unique quantum," which he later called the primeval atom. From Lemaître's poetic scenario arose the current vision of the Big Bang, a model that shapes the thought of cosmologists today as strongly as the idea of crystalline spheres, popularized by Ptolemy, influenced natural philosophers in the Middle Ages.

Unlike Galileo, who was condemned to house arrest for his defense of a sun-centered universe, Lemaître was lauded by the Church for his cosmic breakthrough. Indeed, he ultimately rose to the rank of monsignor and was made a fellow and later president of the Pontifical Academy of Sciences. But he recoiled from any suggestion that his primeval atom had been inspired by the biblical story of Genesis. Throughout his life, he insisted that his theory about the origin of space and time sprang solely from the equations before him.

Lemaître made few notable contributions to cosmology after the 1930s, spending more time on celestial mechanics and pioneering the use of electronic computers for numerical calculations. But he continued to hope that the explosive origin of the universe would be validated by astronomical observations.

In June of 1966, as Lemaître was fighting leukemia, Odon Godart, his successor at the Belgian university, visited him at the Hospital of Saint Peter with news of a report that had appeared in the *Astrophysical Journal* the previous year. That report, which would later win the Nobel Prize for Arno Penzias and Robert Wilson, had detailed the discovery of the cosmic microwave background; Godart brought confirmation that this was the remnant echo of the Big Bang. Lemaître died a few days later, on June 20, knowing that the universe was indeed launched from a compact bundle of energy, just as he had posited more than three decades earlier. ■

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