A sprinkling of stardust

Stellar Alchemy: The Celestial Origin of Atoms
by Michel Cassé (transl. Stephen Lyle)
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NASA/JPL/CALTECH

The ancestral home? We are made up of atoms that were created inside distant stars.

Have you ever wondered how humans fit into the cosmos, what our relationship is to the stars, or how the elements were formed? If so, you should enjoy *Stellar Alchemy*. Michel Cassé, a French astrophysicist, takes the reader on an idiosyncratic journey through the intricacies of modern astrophysics to show how the stars, galaxies, the Universe and humans are interrelated. The book, published in French and now translated into English by Stephen Lyle, is designed for general, but scientifically literate, readers.

The book's focus is on nucleosynthesis, the formation of the elements. The Big Bang created hydrogen, helium and some lithium. Two other light elements, beryllium and boron, are made in interstellar space from interactions between cosmic rays and gas atoms. Over the 14-billion-year lifetime of the Universe, all the other elements have been synthesized inside stars and ejected into space to make new stars, planets and even us. In this process a common element, such as iron, could be transformed into gold — the alchemists' dream.

To explain this requires an understanding of the births, evolution and particularly deaths of stars. Cassé draws colourful comparisons between stellar and human life cycles, although he notes that stars are not alive in the same sense as humans. As stars are the primary components of galaxies, which are strewn across the Universe, the formation of galaxies and the origin and fate of the Universe are also described in great and interesting detail, as are the requisite and related physics: the nature of light, the spectra and atomic physics we use to detect elements in stars, and the various aspects of nuclear physics involved in making the elements.

If the focus is on nucleosynthesis, the book's theme is that we are stardust — the atoms in our bodies were once in stars, making stars our distant ancestors. This idea, popularized by the late Carl Sagan, emphasizes the connections between life on Earth and the formation of elements such as carbon and oxygen in stars. In a personal and reflective manner, Cassé places humanity's origins and future squarely in the cosmos. He includes a nice discussion of the death of our Sun, the Earth and the Solar System, and speculates on humans emigrating from Earth before it is too late. Cassé's optimism shines through as he guarantees we will have mastered space flight by that time, assuming we survive as a species.

The book addresses many of the topical questions in astrophysics. There are lengthy discussions and speculations concerning the dark matter that composes more than 90% of the Universe but cannot be seen, and the recently discovered dark energy, an apparent antigravitational effect that is causing an accelerating expansion of the Universe. Although these topics are still mysterious, Cassé remains the optimist, noting that their explanations may be "unknown but not unknowable".

Cassé's writing style, flowery and poetic and full of historical references, makes even the more technical material accessible to the general reader. The book is also filled with delightful aphorisms, such as "patience is a virtue in the hunt for the invisible" and "the best way of finding a needle in a haystack is to burn the hay". His organization and chapter titles are whimsical, but work — "The Sociology of Stars and Clouds", for

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Science in culture

Divine proportion and the Holy Grail

The idea that the golden section had a special place in Renaissance painting makes for fine fiction but rotten history.

Martin Kemp

Everyone loves a conspiracy. Or so we read in Dan Brown's massive bestseller *The Da Vinci Code*. The conspiracy in this case involves the Priory of Sion, the secret society of which Leonardo was the reputed grand master between 1510 and 1519. The visual secrets include Leonardo's portrayal of St John in the *Last Supper* — young and somnambulant, as was customary — who is re-identified as Mary Magdalene, pregnant with Jesus's child. Mary, as divine mother, is herself the elusive Holy Grail. The linked properties of the 'divine proportion' and the Fibonacci series, beloved of mathematical mystics, provide clues in the decoding of the historical secrets.

Leonardo was certainly aware of the divine proportion (or golden section), illustrating the regular and semi-regular polyhedra in Luca Pacioli's manuscript of the same name in 1498. This section arises when a line is cut so that the ratio of the larger part to the smaller is equivalent to the ratio between the whole and the larger, approximately 1:1.618. The ratio between successive numbers in the Fibonacci series — 1,1,2,3,5,8,13,21,34… — approaches this ratio. There is no obvious problem in thinking that Leonardo knew the work of his namesake, the thirteenth-century mathematician Leonardo Fibonacci da Pisa.

The problem lies in granting a privileged significance to the ratio in the Renaissance, or in any period before the later nineteenth century. Incommensurable ratios were regarded as special, but, in Renaissance design, the ratio $1:\sqrt{2}$, based on Pythagoras' theorem, was used far more widely, not least because it was a simple construction based on the diagonal of a square. It features in architectural planning and occasionally to determine the dimensions of paintings.

An ardent advocate of the ubiquity of the golden section in art and nature was the English writer and Olympic swordsman Theodore Andrea Cook. In his *Spirals in Nature and Art* (1903) and *The Curves of Life* (1914), he adduced instances of the 'phi' ratio, which he named after the legendary Greek sculptor Phidias, in such natural configurations as shells, spiral horns and phyllotaxis. He recognized comparable formations in art and artefacts from across the centuries and around the globe. Such was his faith in the ratio that he used it to disclose the aesthetic secrets of some unlikely candidates, including *The Laughing Cavalier* by Frans Hals, reproduced here from Cook's 1914 book.

A certain ratio: Theodore Cook thought *The Laughing Cavalier* was based on mathematics.

Some artists in the early twentieth century did design their pictures in this way, in particular the Spanish Cubist Juan Gris. But there is no evidence that Renaissance and Baroque artists used such surface geometry in constructing their paintings. Among the thousands of preparatory drawings and the growing number of underdrawings detected in paintings, not one reveals constructional methods based upon the 'secret' division of their surfaces.

There is quite a fashion for the drawing of fat lines on thin reproductions of Renaissance paintings. Draw enough lines on a small image — equilateral triangles, pentagrams and so on — and it is hard not to hit some 'significant' feature. The latest manifestation of this strategy is Bulent Atalay's surprisingly ahistorical *Math and the Mona Lisa* (Smithsonian, 2004), which is determined to credit Leonardo with Cook-like obsessions.

In the service of fiction, the adducing of mathematical secrets in the quest for the Holy Grail is fine if it works as story-telling. As serious history of image-making in the Renaissance it is nonsense. The problems with Brown's code are not the fantasies and anachronisms, but that his invented truth has been taken seriously by those who cannot recognize fiction.

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example. Another nice touch is a glossary of technical terms at the beginning of each chapter. Even with those, however, parts of the book may require effort for those without a background in physics and astronomy.

Some of the figures also seem to be more appropriate for, and have come from, researchers in the field, and some of the tables and appendices are for specialists only. Cassé also stresses the individual and national contributions from French astronomers. While no doubt deserved, their frequent mention seems somewhat out of place. But these are minor quibbles, and Cassé's interesting story about the relations between the stars and humans, and his joy in the subject, carry the reader along on a pleasant journey. ■

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