BOOKSHELF

‘First Light’ Review: A Stellar Start

Scientists scan the heavens for the elusive remains of the Cosmic Dawn.

By Marcia Bartusiak
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Astronomer Edwin Hubble began the journey in the 1920s. He discovered that our galaxy was not alone in the universe—that the Andromeda nebula was a separate galaxy, far beyond the borders of the Milky Way. Over the succeeding years, Hubble proceeded to measure the distances to more faraway galaxies, out to some several hundred million light-years. But then, he wrote in 1936, “we reach the dim boundary—the utmost limits of our telescopes. There, we measure shadows, and . . . pass on to the dreamy realms of speculation.”

But, oh, how far we have come. When looking outward, Hubble was also looking back in cosmic time. Yet he reached only a fraction of the distance back to the big bang. Today astronomers can observe the cosmos when it was a mere baby—only about 400,000 years old—via the cosmic microwave background, the remnant echo of our universe’s explosive beginning. And advanced telescopes, both on the ground and in space, are now viewing the birth of galaxies out to a distance of some 13 billion light years.

FIRST LIGHT

By Emma Chapman
Bloomsbury, 304 pages, $28

Does that mean astronomy’s job is nearly done when it comes to tracing our universe’s evolution? Hardly. “Despite the exponential increase in technology and progress, there is a period in our Universe that, until recently, we had no observations of at all,” writes

Emma Chapman, a Royal Society Fellow at Imperial College in London. "From 380,000 years after the big bang to about 1 billion years after it, the Universe has remained in the Dark Ages. . . . In human terms, the missing cosmological data is equivalent to missing everything from the moment of conception to the first day of school, perhaps apart from a single ultrasound."

This crucial period is when the brilliant big bang plasma cooled and dimmed, giving way to a stark blackness as protons and electrons joined to form the first hydrogen atoms. In time these atoms coalesced into clouds that launched the portion of this era called the Cosmic Dawn, when mammoth stars several hundred times the mass of our Sun fiercely ignited for the first time, reached surface temperatures of 100,000 Kelvin (compared to our Sun's far cooler 5,800K) and then quickly died. "And yet in such short lifetimes, those stars are the ones most responsible for changing the Universe," notes Ms. Chapman. "As they roared to life, they illuminated the Universe, irradiating it and seeding it with metals that could then form stars, planets and us."

"First Light," a thoroughly engaging tale that allows us to see science in the making, chronicles current attempts to reveal this hidden era—what we know and what we don't know. Ms. Chapman herself is in the thick of this endeavor and serves as a wonderful guide, whose voice is reminiscent of Carl Sagan's , although with an extra and very welcome dollop of impish humor. I know of no other astronomy book that includes references to Doctor Who, Tutankhamen and cyanobacteria in its metaphors and analogies. From page to page, you get caught up in her excitement, as when she finds an unexpected exclamation point in a journal article: "It's simply not done," she exclaims. "I love seeing this enthusiasm and humanity in scientific papers."

To get us started, the author opens with some lessons on the nature of light, the various types of stars and the nuclear reactions within them. But the first stars created in the Cosmic Dawn were very different from the ones that now surround us. When born they contained no "metals"—astronomical shorthand for all the elements beyond simple hydrogen and helium. These first-generation stars had yet to be enriched with the oxygen, carbon and nitrogen that are fused within stars and then spewed into space via stellar explosions.

Astronomers have long sought these pristine first stars, and by the 1980s it was thought to be a scandal that extensive searches came up empty. To Ms. Chapman, they are "the rare Beanie Baby missing from our shelves, or the mint-condition Penny Black gap in our stamp collection. To find them, we need fresh ideas, resources and stamina."

One clever idea is to search for the earliest radio "song" of hydrogen, a 21-centimeter wavelength emitted by the neutral atoms, and then look for an abrupt change in the tune as the hydrogen gets excited by the radiation from the first stars. In 2018 a set of antennas in western Australia seemed to have captured this unique signal, which had been stretched out to a wavelength of 4½ meters as it traveled through the expanding universe, giving us "the most basic morsel of information: a date of birth," writes Ms. Chapman. The first stars appeared to have arisen a mere 180 million years after the big bang.

Or maybe not. Certain properties of the signal didn't match what astronomers had been expecting, suggesting that something else was involved, perhaps dark matter or some other unknown background accompanying the hydrogen, which muddied the interpretation. She shows us how scientific progress usually works: "More often, instead of 'Eureka! I've got it,' it is 'That looks weird! Hang on, what is that?'"

Another approach is to carry out a bit of stellar archaeology: look around our local celestial neighborhood and seek out the smallest first-generation stars still burning away. Stars today have a typical metal content of 2%; the first stars have none. So far, astronomers have found only a handful that are ultra metal-poor. One star was 1/1,000,000th more iron-poor than the Sun. Close, but no cigar. "It's the equivalent of faking an Egyptian mummy almost perfectly, but leaving the body with a smartwatch on,"

writes Ms. Chapman. It was not an original star, but rather a close descendant that had gotten its pinch of iron from a previous generation.

Ms. Chapman's grand finale involves the "Epoch of Reionization" right after the Cosmic Dawn. And, yes, she agrees with you that it's a "terrible, terrible name. It took me several months," she confesses, "to spell it confidently, let alone pronounce it." Simply put, it's the era when the first stars' intense radiation re-energized the neutral hydrogen suffused through space, in other words "ionizing" it back into separate protons and electrons. She describes these bubbles of ionized hydrogen, spreading outward over hundreds of millions of years, as "the footprints of the first stars." Her work involves continuing to look for that moment when neutral hydrogen's radio song suddenly goes silent, as the ionized hydrogen can no longer speak in the same way. This is a thankless job, as she must first subtract out all the other noises of the universe. "It's like listening to a phone conversation while walking past a pneumatic drill," she notes, which is why they have yet to be sure they've found it with full confidence. Why go to all this trouble? Because it will reveal the celestial objects—such as quasars, X-ray binaries, and dwarf galaxies—that existed during this period of cosmic history and show how they behaved, an amazing astronomical observation from so far away.

There are moments in "First Light" when the text might be more at home in an astrophysical journal, but even in those sections the book offers the reader insights on the intricate data and analysis required to reveal the universe's mysteries. I eagerly await a second edition when the Cosmic Dawn is at last viewed in its full glory—perhaps using a future telescope array mounted on the far side of the Moon.

—Ms. Bartusiak is Professor of the Practice emeritus in the MIT Graduate Program in Science Writing and the author of seven books on the frontiers of astrophysics and its history, including "The Day We Found the Universe" and "Black Hole."