Curios & Conundrums

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Music of the Spheres

EINSTEIN, RELATIVITY, AND BLACK HOLES

A fantastic overture to time travel

The universe was never the same again. After years of struggle, Albert Einstein finally mapped out his general theory of relativity in 1915. It's a story his second wife Elsa loved to tell. She recalls the celebrated physicist being out of sorts one morning, pacing around their Berlin apartment, refusing to eat breakfast. He sat down at their grand piano and played, stopping occasionally to make notes. He told his wife of a "wonderful idea" with which he was wrestling, but refused to tell her more. After a while longer at the piano, he went up to his study and didn't leave. Two weeks later, he came back down and announced to Elsa that he had come up with his final formulation of general relativity, a theory called "probably the greatest scientific discovery ever made." Einstein said it was a theory "of incomparable beauty."

Einstein had upended the clockwork certainties of Euclid and Newton. In their stead, Einstein had devised a whole new geometry for the universe. He showed that space is not a container in which the force of gravity acts upon objects; rather, space has its own dynamic organization (based on the amount of mass) that determines how objects move through it. Space and time, now known as spacetime, bend and stretch in a sophisticated cosmic dance. What we call gravity isn't a force, it's an expression of the shape of spacetime.

> *"Einstein had cracked open the universe, and time along with it.*

Einstein had cracked open the universe, and time along with it. What followed was wild.

Within a year of publishing his final formulation, an astrophysicist used Einstein's equations to predict the existence of black holes, objects so fantastic they seem tailor-made for science fiction writers and fans of time travel. Because of their incredible density, time is expected to slow down near black holes. And certain types of black holes inspire some physicists to suggest that they can twirl spacetime so extravagantly that time would have more than one trajectory, more than one future. At the heart of a black hole is a singularity, where spacetime becomes infinite. At that point, who knows what happens? Is it a portal to other universes or dimensions? Perhaps a connection to another black hole? That connection is called a wormhole, which can best be imagined as a shortcut through spacetime, connecting two different points in space or two different points in time. Einstein's discovery of relativity made time travel a very real possibility. (Whether humans and their machines can survive, let alone steer their way through, such phenomena is another matter altogether.)

Einstein himself never believed time travel was possible. He did, however, predict something known as the twin paradox. Einstein theorized that an astronaut travelling away from Earth at high speed would age slower than a sibling back on Earth. Understanding this phenomenon, called time dilation, is critical for such inventions as the GPS in your phone. Time passes slower for satellites orbiting the Earth, so critical adjustments have to be made to sync them up with clocks on Earth.

As for black holes, Einstein disavowed them too; he didn't live long enough to see proof of their existence.

Nothing is stranger than black holes. Direct proof of their existence was late in coming, but it would have delighted Einstein, despite his initial misgivings, because the proof was musical.

"If I were not a physicist, I would probably be a musician," Einstein once said. "I often think in music. I live my daydreams in music. I see my life in terms of music."

That Einstein came to formulate general relativity at the piano is no random detail. Music had a profound influence on Einstein's theoretical thinking. He wasn't just noodling around on the piano, going for a metaphorical walk just to clear his head. It was through music that Einstein, an accomplished musician, conceived of the cosmic dance between space and time.

"Music was the driving force behind [my] intuition," Einstein said, when discussing relativity. "My discovery was the result of musical perception."

What exactly Einstein meant by this is hard to unpack. On one hand, he was talking about the simplicity of his theory — that somehow, it reflected a basic truth that existed in

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Joke of the day

There once was a lady named Bright,
Who travelled much faster than light.
She departed one day,
in a relative way,
And returned on the previous night.

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nature. He talked about music the same way. His favourite composer was Mozart, whose music, Einstein said, "was so pure that it seemed to have been ever-present in the universe, waiting to be discovered by the master."

> *Many physicists understand the universe as a musical entity.*

On the other hand, he was expressing a sort of left-brain/right-brain scenario. Einstein did not think in symbols nor equations, he said, but rather in images, feelings, and musical architectures.

Many physicists understand the universe as a musical entity, from the tiny vibrating building blocks that animate string theory, to the primordial gravitational waves that echo the creation of the universe at the big bang. It's an understanding that goes back to the Greeks.

There is a mathematical basis for the laws of harmony. Musical terms like octave and perfect fifth express a mathematical relationship among notes. Pythagoras found that relationship beautiful, and he felt the math applied equally to planetary motion as it did to music. In fact, Pythagoras thought celestial bodies made music: the music of the spheres.

In September 2015, following a years-long upgrade, scientists at LIGO (Laser Interferometer Gravitational-Wave Observatory) turned on twinned observatories in Louisiana and Washington state. Soon after, they detected gravitational waves for the first time. What they recorded was the sound of a pair of distant black holes spinning around each other as they collapsed into one, releasing huge amounts of energy in the process. That energy, in the form of gravitational waves, rang spacetime like a bell. After travelling staggering distances over an incredible amount of time, the ringing was infinitesimally faint, but its meaning was clear. The ringing was the sound of relativity. The proof of black holes happened almost exactly a hundred years after the theory of general relativity was discovered, providing a sublime musical coda to Einstein's cosmic dance. ▫

In the Middle Ages, the atom was defined as the smallest possible division of time.