Lia Halloran's vivid paintings capture the drama and mystery of various cosmological events.

BOOKS *et al.*

ASTRONOMY

Fantastical phenomena, illustrated

An astrophysicist and an artist craft evocative portraits of warping spacetime

By **David Kaiser**

Not so long ago, black holes seemed enigmatic, even to the experts who studied them. The idea was both alluring and fantastical: hypothetical hunks of matter compressed to enormous densities, warping their surrounding spacetime so strongly that even light could not escape. Although the phenomenon seemed to follow from the equations of Albert Einstein's general theory of relativity, empirical evidence that black holes actually existed remained suggestive but indirect until February 2016, when members of the Laser Interferometer Gravitational-Wave Observatory (LIGO) published data from the first compelling detection of gravitational waves. Since then, the LIGO Scientific Collaboration has published dozens of comparable signals, most of them attributable to black hole collisions.

In April 2019, another globe-spanning international collaboration, the Event Horizon Telescope, released its own shocking first detection: a now-iconic image of the black hole at the center of the nearby galaxy Messier 87. The black hole sits amid a swirl of superheated plasma, a shadow warping the light from nearby matter in exactly the Escher-like, looping fashion that theoretical physicists had predicted decades earlier, on the basis of Einstein's equations. In May 2022, the group released an equally stunning image of the black hole anchoring our own Milky Way galaxy.

More recent data, released in late June 2023 by the North American Nanohertz Observatory for Gravitational Waves, or NANOGrav, identify a constant thrum of cosmic static: a stochastic background of gravitational waves, rattling around the cosmos from every direction in the sky. The NANOGrav data are most readily accounted for by the motions of a huge population of supermassive black holes, dotted across the Universe, each object millions or billions of times more massive than our Sun.

The Warped Side of Our Universe
Kip Thorne and Lia Halloran
Liveright, 2023. 240 pp.

These days, black holes seem not only possible but plentiful. Yet being ubiquitous has not made them mundane. In *The Warped Side of Our Universe*, physicist Kip Thorne and artist Lia Halloran blend evocative imagery with prose-poem narration to share some of the wilder implications of exotic gravitational phenomena with nonspecialist readers.

Thorne has been a pioneer in the study of gravitation for more than half a century; he shared the Nobel Prize in Physics in 2017 as part of the LIGO leadership team. He also has decades of experience describing esoteric phenomena in accessible ways. Since 2009, Thorne has struck up a series of collaborations with artists, filmmakers, and musicians, experimenting with novel ways to convey the majesty and the strangeness of black holes, gravitational waves, and more-fantastical—as yet hypothetical—phenomena such as wormholes and time travel. Halloran, an accomplished visual artist whose work has been featured in two dozen solo exhibitions around the world, developed an interest in depicting scientific topics during an early stint at the famous Exploratorium in San Francisco and studied astronomy while pursuing her graduate training in painting.

Thorne and Halloran worked on this book over the course of 13 years, a period that included the stunning first results from LIGO and the Event Horizon Telescope and that set the stage for NANOGrav. The authors' process, as recounted in a brief preface, was every bit as looping and nonlinear as Einstein's equations—informal discussions led to sketches and short drafts of prose; refined drawings inspired updated wording, and vice versa. Midway through their efforts, Thorne decided to transform his sparse written contributions into verse, to better complement the swirling, ocean-like eddies emerging in Halloran's paintings.

The result is an ambitious art-science artifact inviting readers to ponder black holes, wormhole-like tunnels through spacetime itself, and the gravitational-wave signals emanating from such strange cosmic constituents. The material is grounded in cutting-edge research. In some places, Thorne draws on novel vocabulary that he and his graduate students coined only a few years ago to help make sense of their sophisticated numerical simulations, while Halloran's engrossing images convey a visceral sense of stormy spacetime ruptures. My favorite section features Thorne's personal reflections on the LIGO collaboration, which involved human-scale interactions at least as complicated as anything described by Einstein's mathematics.

The main body of the book aims more to evoke than to explain. Thorne provides helpful resources in the back of the book, with a more traditional popular-science exposition, plus a glossary, timeline, and annotated bibliography of additional materials to explore. Complementing these other excellent resources, *The Warped Side of Our Universe* offers a creative, original portrait of a scientific community, and a broader universe, in motion. ■

The reviewer is at the Program in Science, Technology, and Society and the Department of Physics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA. Email: dikaiser@mit.edu

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ILLUSTRATION: LIA HALLORAN

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