Field Guide To the Universe
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Field Guide To the Universe

BLACK HOLES AND TIME WARPS
Einstein's Outrageous Legacy
By Kip S. Thorne
Norton. 619 pp. $30

By Marcia Bartusiak

SEVERAL weeks ago astronomers reported that they had spied the most distant galaxies ever observed. You may not have noticed, because front-page headlines were proclaiming that the Hubble Space Telescope had revealed the best evidence yet for the existence of a black hole, that infamous celestial object from which no light and matter can escape. The candidate, a whopper with the mass of a few billion suns, lurks in the heart of a far-off galaxy in the Virgo constellation.

These days, a black hole is astronomy's top celebrity, the Roseanne Arnold of the cosmic jet set: powerful, preposterous and a publicity-grabber whenever it hits the news. In the public's mind, distant galaxies are passé.

So it's an auspicious time for Kip Thorne to publish *Black Holes and Time Warps.* Readers seeking to go beyond today's headlines will not find a higher authority (or a better storyteller) to discuss the cosmos's most bizarre features. For nearly 30 years, Thorne, a professor of theoretical physics at the California Institute of Technology, has guided dozens of graduate students and postdoctoral researchers of general relativity, and, as the subtitle of his book indicates, black holes and warps in space-time are the most outrageous legacy of this revolutionary theory.

"Some of the physics may be tough going," the author cautions in his preface. Believe me, it is. With over 600 pages of text and notes, Thorne digs deeply into his subject: from the vision of space and time established by Isaac Newton and overturned with a jolt by Einstein, to the uncharted sub-submicroscopic territory ruled by "quantum gravity," a law that physicists are still struggling to formulate.

Each set of rules transcends the one before it, "forcing the Universe to behave as it does," says Thorne. Although his material is formidable, there is nary an equation in sight, and an abundance of drawings and sidebars elucidate the major ideas—delicious details for those who yearn for more than mere hand-waving in a popular science book. But this work is not just a monograph on the theory of general relativity; it is an engaging and lucid history of black-hole research, the most comprehensive review to date.

Black holes are a natural consequence of general relativity, which views space-time as a flexible mat that a mass, such as a star, can bend and fold like rubber. More than half a century ago, a few researchers realized that if a dying star were heavy enough, it would collapse and collapse, carving a gravitational pit in the space-time canvas so deep that no bit of light or matter could ever climb out. But nearly every expert then, including Einstein, blanched at this outlandish notion. "Black holes just didn't 'smell right,' " Thorne writes; "they were outrageously bizarre; they violated Einstein's intuitions about how our Universe ought to behave."

This deep skepticism didn't diminish until the 1960s, when relativists took advantage of work linked to nuclear-weapon development. Computer codes, used to design hydrogen bombs, were adapted to mimic the implosions of stellar cores, and total gravitational collapse was shown to be inevitable. The noted Princeton theorist John A. Wheeler, Thorne's graduate-school advisor, helped a bit, too: In 1967, he gave the black hole, essentially nameless until then, its distinctive moniker. The catchy phrase caught the public's imagination (and caused blushes for a while in France where *trou noir* has obscene connotations).

A golden age of black-hole studies dawned. With pen, paper, and computer, researchers began to play with charged holes, spinning holes, pulsating holes and deformed holes. The celebrated British theorist Stephen Hawking made his name by proving mathematically that black holes can even evaporate and explode. Others showed how gigantic black-hole engines might be powering the terrifically energetic quasars and active galaxies populating the universe.

A black hole was not just a bottomless space-time pit; it had personality! And Thorne describes it with style: "A black hole should be able to spin, and as it spins it should create a tornado-like swirling motion in the curved spacetime around itself. Stored in that swirl should be enormous energies, energies that nature might tap and use to power cosmic explosions . . . The horizon of the big hole should pulsate in and out, just as the surface of the Earth pulsates up and down after an earthquake, and those pulsations should produce gravitational waves—ripples in the curvature of space-time that propagate out through the Universe, carrying a symphonic description of the hole."

Thorne, a loner who dislikes intense competition, began to focus his attention on gravity waves in the 1960s because few scientists were then studying them. Today physicists are constructing gravity-wave "telescopes" to detect these subtle swells in space-time. It's a chancey (and controversial) enterprise, but a detection would usher in a new era of astronomy and clinch the existence of black holes once and for all.

THE MOST SPECULATIVE section of *Black Holes and Time Warps*—and also the most fascinating—describes the physics of wormholes, short-cuts through hyperspace to other reaches of the universe (and, amazingly enough, a bona fide solution to Einstein's field equation). Thorne started studying these cosmic tunnels by happenstance, after his friend Carl Sagan, then working on the novel *Contact,* asked Thorne if there was a scientifically legitimate means for his characters to dart about the cosmos with ease. Soon Thorne and his students figured out how to use wormholes as time machines (but only after assuming that they had a technological know-how countless millennia beyond our current capabilities).

It's fun to think that time travel, a concept once relegated to science fiction, might be permissible, if only in theory. A comprehensive theory of quantum gravity is first needed, though, and that could be decades away. Hawking has bet Thorne that nature abhors a time machine. What happens if children were to go back in time and kill off their ancestors before they were born? Given such paradoxes, Thorne suspects he'll lose the bet.

Black Holes and Time Warps is a masterful and intriguing work, an eclectic mix of challenging physics, firsthand insights and amusing anecdotes about the leading figures in gravitational research. "May real historians forgive me," he writes, "and may nonhistorians thank me." Thank you, Professor Thorne. ■

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At top: Drawing of quasars and radio galaxies based on observational data developed by Sterl Phinney of Caltech and others; center: comparison of the sizes and mean densities of the Sun, Earth, and the white-dwarf star Sirius B; bottom: a diagram of a kilometer-long wormhole through hyperspace linking the Earth to the vicinity of Vega, 26 light-years away.

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