Name: _____ Date: _____

Too Strong for Light

Reading level 10 (6th grade) · 1025 words

Kenji threw a baseball straight up as hard as he could. It climbed, slowed, stopped for a moment against the sky, and fell back into his glove. Everything thrown upward comes back down, because Earth's gravity pulls on it. But how fast would the ball have to go to escape for good? The answer is about 25,000 miles an hour, far faster than any arm could ever throw. So what is a black hole? It is a place where the speed you would need to escape is faster than light itself.

Light travels faster than anything else in the universe, so if light cannot climb out, nothing can. That is why a black hole is black. But the name is a bit of a trick. A black hole is not an empty hole at all. It is an enormous amount of matter crushed into a very small space. Its edge is called the event horizon. It is not a surface you could stand on, like the ground. It is a boundary, more like a one-way door. Things can go in, but nothing comes back out.

The size of that boundary depends on how much matter is inside. One black hole not far from us, as these things go, holds nearly ten times the mass of the Sun. Its event horizon reaches only about 17 miles from the center, a distance a car could drive in well under an hour. So where do black holes like that come from? A very big star ends its life in a huge blast called a supernova. If the star was about twenty times heavier than the Sun or more, its core collapses into a black hole.

Kenji's first question was the obvious one. If a black hole gives off no light, how does anyone find one? Usually, they look at its neighbors. Many black holes have a partner star. The black hole pulls gas off the star, and the gas swirls into a flat, spinning disk that gets so hot it glows with X-rays. Telescopes in space can pick up that glow. This trick has turned up about fifty likely black holes in our galaxy. Scientists think there may be as many as a hundred million in the Milky Way, most of them never spotted.

The quiet ones are harder. A black hole with nothing to feed on gives off no light. Astronomers call it dormant, which means sleeping. To find one, watch for a star that wobbles for no clear reason. It is like watching a person on a dark street sway and stumble. You cannot see the big dog on the leash, but you can tell it is pulling. By 2024 the Gaia space telescope had found three this way. The nearest one astronomers are fairly sure of is about 1,560 light-years away. That is close for a black hole, but still very far.

People often picture black holes as cosmic vacuum cleaners, sucking up everything in sight. They are not. From a safe distance, a black hole tugs on things exactly as hard as a star or planet of the same mass would. Imagine that the Sun were somehow replaced by a black hole with exactly the same mass. The planets would keep circling in the same orbits as before. The

solar system would get very dark and very cold, but Earth would not be pulled in. Our Sun cannot turn into a black hole anyway. It is not heavy enough.

Close to a black hole, though, things get strange. Gravity there changes so fast that a spacecraft falling in would feel a much stronger pull on its front than on its back. It would be stretched long and thin. Scientists really do call this spaghettification. Time behaves oddly, too. To someone watching from far away, a clock near a black hole would seem to tick more slowly than a clock farther out. Kenji tried to imagine his watch running slow and decided he would rather watch from very far away.

Our own galaxy has a giant black hole at its center, called Sagittarius A*, which is said "A-star." It holds about four million times the mass of the Sun. Two teams of astronomers, led by Andrea Ghez and Reinhard Genzel, spent years tracking the stars that race around it. One star, called S2, swings all the way around the center every sixteen years. The stars move so fast that only something extremely heavy and extremely small could be holding them. That work won the Nobel Prize in Physics in 2020.

In 2015, scientists found a completely new way to notice black holes: by feeling them. Two detectors in the United States, called LIGO, picked up tiny ripples in space itself. The ripples came from two black holes, one about 29 times and one about 36 times the mass of the Sun, crashing together and merging into one. That crash happened about 1.3 billion years ago, so the ripples had been traveling toward Earth all that time. Nobody had ever caught black holes colliding before.

People sometimes ask whether you could make a black hole. Some people even worried that a giant machine in Europe, the Large Hadron Collider, might make one by accident. It smashes tiny particles together. According to Einstein's theory of gravity, it cannot. A few unproven theories predict that it might make microscopic ones. But even those theories say such tiny black holes would fall apart the instant they formed, long before they could grab anything. Kenji found that a relief. He also found it a little disappointing.

Even now, there is a great deal that nobody knows about black holes. No one knows what matter looks like inside the event horizon. Einstein's theory predicts that the very center is a point crushed infinitely small, but scientists are not sure whether that point is real or only a sign that the math has broken down. No one knows how some giant black holes grew so huge so soon after the universe began. Kenji threw his baseball up one more time and caught it. Where would it go if it never came back?

Questions

1. Why is a black hole black?

A. The speed needed to escape it is faster than light, so no light gets out
B. It is made of dark rock
C. It is too far away to see

2. Why does the book say the name "black hole" is a bit of a trick?

A. Black holes are bright
B. A black hole is not empty; it is a huge amount of matter crushed into a small space
C. Black holes are shaped like squares

3. In this book, what does "dormant" mean?

A. Very hot
B. Very large
C. Quiet, giving off no light, like sleeping

4. How can astronomers find a dormant black hole?

A. By watching a star wobble as something unseen pulls on it
B. By listening for its sound
C. By shining a flashlight at it

5. What would happen if a black hole with the Sun's mass replaced the Sun?

A. Earth would be sucked in at once
B. The planets would keep their orbits, but it would be dark and cold
C. Earth would fly off into space

6. What did LIGO detect in 2015?

A. A picture of a black hole
B. A new planet
C. Ripples in space from two black holes merging

Words to know

gravity: pulling force
horizon: black hole's edge
dormant: sleeping, quiet
supernova: exploding star
spaghettification: stretching thin

Answer key: Too Strong for Light

1. A. The speed needed to escape it is faster than light, so no light gets out
2. B. A black hole is not empty; it is a huge amount of matter crushed into a small space
3. C. Quiet, giving off no light, like sleeping
4. A. By watching a star wobble as something unseen pulls on it
5. B. The planets would keep their orbits, but it would be dark and cold
6. C. Ripples in space from two black holes merging