TOEFL Listening Lesson 21

Setting: A college-level *Astronomy* class.

Questions

1. What is the main topic of the lecture?

A. The evolution of massive stars into neutron stars

B. How black holes distort time and space

C. The different ways astronomers detect black holes

D. The differences between supernovae and black holes

2. What is one way astronomers identify a black hole in a binary star system?

A. By detecting the intense magnetic fields emitted from both stars

B. By observing gravitational waves before the stars collide

C. By measuring the mass of an unseen object the visible star is orbiting

D. By analyzing the sound waves produced in the surrounding gas

3. What evidence led astronomers to believe that a supermassive black hole exists at the center of the Milky Way?

A. A strong gravitational wave signal was detected near the galactic core

B. High levels of gamma radiation were found in the region

C. Stars were seen orbiting an invisible and massive object

D. An enormous dust cloud blocked all visible light in that area

4. Why does the professor mention the accretion disk around a black hole?

A. To explain why black holes are larger than they appear

B. To illustrate how black holes can emit visible light

C. To show how astronomers can detect black holes through X-rays

D. To demonstrate that black holes create magnetic fields

5. Why does the professor talk about the LIGO observatory?

A. To explain how gravitational waves confirm the existence of white dwarfs

B. To describe a new way scientists can detect black hole collisions

C. To show that visible light is not always necessary for space observations

D. To argue that black holes may not be as dense as previously believed

Script

Professor:
"Let's dive into one of the most intriguing and mysterious phenomena in the universe: black holes. Today, our focus will be on how astronomers detect black holes, given that they don't emit any light and therefore cannot be observed directly through traditional telescopes.

First, let's briefly review what a black hole is. A black hole is formed when a massive star—several times larger than our sun—reaches the end of its life and undergoes a gravitational collapse. The core collapses inward, compressing all of its mass into an incredibly small volume, creating a point of infinite density called a singularity. Surrounding the singularity is the event horizon, a boundary beyond which nothing, not even light, can escape. The gravity is so strong at this point that it warps space and time.

Now, because black holes don't emit light, we can't see them the way we see stars or planets. So how do we find them? The key lies in observing their effects on the environment around them. We use **indirect evidence** to infer their presence. One of the first methods astronomers used—and still use today—is analyzing the motion of nearby stars and gas clouds.

Imagine a star that appears to be orbiting around… well, nothing. If we carefully track the star's movement and apply Newtonian and Einsteinian physics, we can calculate the mass of whatever it is orbiting. If the object is incredibly massive, say several times the mass of the sun, and there's no visible light source at that location, the most likely explanation is a black hole. This is how we discovered one of the best-known black holes, located at the center of our Milky Way galaxy—Sagittarius A*. Stars near the center of our galaxy orbit around something massive, compact, and invisible. The only plausible explanation is a supermassive black hole.

Another method involves **X-ray emissions**. When matter gets too close to a black hole, it doesn't just fall straight in. Instead, it often spirals around the black hole in what we call an accretion disk. As the material in this disk gets pulled inward, it accelerates and becomes extremely hot—hot enough to emit X-rays. These high-energy X-rays can be detected by space telescopes like NASA's Chandra X-ray Observatory. So, if we detect a strong X-ray source coming from a region of space where there is no visible star, and if this region also shows signs of a gravitational pull on nearby objects, we may be looking at a black hole.

This brings us to **binary star systems**, which provide some of the clearest indirect evidence of stellar-mass black holes. In these systems, a visible star appears to orbit an unseen companion. When astronomers study the visible star's orbital behavior—its velocity, periodicity, and the gravitational influence it experiences—they can determine the mass of the companion. If the companion's mass exceeds about three times the mass of the sun and it emits no light, it's a strong candidate for being a black hole. Some of these systems also emit X-rays, making the case even stronger.

More recently, another groundbreaking form of evidence has come into play: **gravitational waves**. These are ripples in the fabric of spacetime itself, predicted by Einstein's general theory of relativity. In 2015, the LIGO observatory made the first detection of gravitational waves—created by the collision of two black holes. This was a huge milestone in physics. When two black holes orbit each other and eventually merge, they release an enormous amount of energy in the form of gravitational waves. These waves travel across the universe, and although they're incredibly faint by the time they reach Earth, we now have detectors sensitive enough to pick them up.

Gravitational wave astronomy has added an entirely new tool to our observational arsenal. It's the closest we've come to observing black holes directly—not through light, but through the distortion of spacetime itself. These discoveries have not only confirmed the existence of black holes, but have also allowed us to learn about their masses, their spins, and even how often they merge.

So, to summarize: astronomers detect black holes not by looking for the black holes themselves, but by observing their effects. These include the motion of nearby stars, the X-rays emitted by accreting matter, and, most recently, the detection of gravitational waves caused by black hole mergers. Each of these methods offers a different piece of the puzzle, helping us better understand these mysterious objects.

Black holes, once purely theoretical, are now a well-established part of astrophysics. Thanks to innovative tools and techniques, we're learning more about them every year—and the more we discover, the more questions arise. That's the beauty of science."

Answers

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Correct Answer: C. The different ways astronomers detect black holes

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Correct Answer: C. To show how astronomers can detect black holes through X-rays

5. Why does the professor talk about the LIGO observatory?

Correct Answer: B. To describe a new way scientists can detect black hole collisions