**Week 11: General Relativity and Black Holes**

When Einstein wrote his **general theory of relativity**, he found a new way to describe gravity. It was not a force, as Sir Isaac Newton had proposed, but a consequence of a distortion in space and time, conceived together in Einstein’s theory as **'space-time'**. According to Einstein, matter and energy exist on a background of space and time. Objects distort the fabric of space-time based on their mass - more massive objects have a greater effect.

One of Einstein's contemporary astronomers - a theoretical physicist named [Karl Schwarzschild](http://turnbull.mcs.st-and.ac.uk/history/Biographies/Schwarzschild.html) was attracted to general relativity and shortly before his death in 1916, Schwarzschild completed his work titled On the Field of Gravity of a Point Mass in the Theory of Einstein, which became one of the pillars of modern relativistic studies. It provided support for a, then, seemingly implausible situation about the effects of severely compressed matter on gravity and energy.

Schwarzschild realized the **escape velocity** from the surface of an object depends on both its mass and radius. If the radius of a given mass is small enough, the escape velocity will increase until it reaches the speed of light. At that point, neither matter nor radiation can escape from the object's surface. Additionally, atomic or subatomic forces become incapable of holding the object up against its own weight. Therefore, the object collapses into an infinitesimal point - the original object disappears from view and only its gravity remains to mark its presence. As a result, it creates a bottomless pit in the fabric of space-time.

Scientists now refer to an object with zero-volume but all of its mass as a [**singularity**](http://curious.astro.cornell.edu/question.php?number=55). Schwarzschild also explained that a singularity was surrounded by a spherical gravitational boundary that forever trapped anything that ventured within. This boundary was called the [**event horizon**](http://archive.ncsa.uiuc.edu/Cyberia/NumRel/BlackHoleAnat.html). Nothing, not even light can escape from within this event horizon. It is called a horizon, because like the horizon on Earth, we cannot see beyond it.

Schwarzschild presented a formula that enabled the size of an event horizon to be calculated. This is now known as the Schwarzschild radius and it marks the edge of a bottomless pit in space-time. Venture beyond the brink and you will never return.

The idea of a singularity troubled many scientists, including Einstein. Leading thinkers of that period could not imagine conditions that would create a singularity but now we know they are common throughout the Universe. Over the past decade researchers realized that most galaxies have at least one black hole in residence in their central regions. Even our home galaxy, the Milky Way, has a four million solar mass [black hole](http://www.orbitsimulator.com/gravity/articles/mwblackhole.html) located at its center, about 27,000 light years from Earth.

Black holes are one of only a fairly small number of cases in the history of science where a theory was developed in great detail as a mathematical model before there was any evidence from observations that it was correct. Indeed, this used to be the main argument of opponents of black holes. How could one believe in objects for which the only evidence was calculations based on the dubious theory of general relativity?

**1 Exam Practice:** In the text, find meanings to the following words.

Improbable to be on every side

Tiny to go somewhere that is dangerous and unknown

Infinite edge

A hole important

Talk about frequent

**2 Grammar:** ING or infinitive?

My dad finally gave up **smoking / to smok**e.

He denied **stealing / to steal** the money.

I enjoy **listening / to listen** to music.

Can you afford **buying / to buy** so many presents?

You should practice **speaking / to speak** English every day.

I finally managed **finding / to find** my passport.

I’m looking forward to **seeing / see** you next time.

He offered **baby-sitting / to baby-sit** my child this weekend.

I refuse **waiting / to wait** any longer.

He pretended **being / to be** asleep.

**3 Exam Practice:** Word Formation

The inventor says it was \_\_\_\_\_\_\_\_\_\_\_\_\_\_ that gave her the idea for the gadget. LAZY

Without an electronic device such as a laptop or MP3 player as a \_\_\_\_\_\_\_\_\_\_\_\_\_, DISTRACT

she finds her journey to work totally \_\_\_\_\_\_\_\_\_\_\_\_\_. BEAR

In a moment of \_\_\_\_\_\_\_\_\_\_\_\_\_\_, she decided to invent something, INSPIRE

which would be easy to \_\_\_\_\_\_\_\_\_\_\_\_. HAND

You can use your laptop \_\_\_\_\_\_\_\_\_\_\_\_\_ of where you are. REGARD

She found an \_\_\_\_\_\_\_\_\_\_\_\_\_ into her idea. INVEST

She wants to come up with other \_\_\_\_\_\_\_\_\_\_\_\_\_\_. PRODUCE

The gadget helps protect people’s personal \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. BELONG

**4 Prepositions**

I’d like to continue \_\_\_\_\_ my project. A research project \_\_\_\_\_ ecology has been stopped. My research \_\_\_\_\_ the influence of stress situations on students has been awarded by a prize. There has been a sudden increase \_\_\_\_\_ unemployment. His book investigates the rise \_\_\_\_\_\_ trade unionism in the region. Only 56 turtles nestled this year, a fall \_\_\_\_\_ 20% from last year. The spread \_\_\_\_ new technology has led to dramatic changes in the workplace. The exam consists \_\_\_\_ two parts. It’s difficult to concentrate \_\_\_\_ your work. I’d like to thank everyone who contributed \_\_\_\_ the success of this project. You should always insist \_\_\_ test drive before buying a car.

**5 Listening:** Travel in Time

<http://www.openculture.com/2018/02/whats-the-origin-of-time-travel-fiction.html>

1 What does the narrator mean when he says the idea of time travel is as old as regret?

2 How is the sense for cause and effect connected to the idea of time travel?

3 What is the earliest mark of the beginning of the time travel genre?

4 Why does the narrator contrast the time travel genre to a cyborg?

5 What were the consequences of publishing Darwin’s *On the Origin of Species*?

6 What is Bellamy’s book *Looking Backward* about?

7 What was the guiding principle of utopian stories?

8 What are the possible ways of heroes getting into future in the utopian romance?

9 Why are time travel books and movies obsessed with rules?

Sources:

Bell, Jan and Roger Gower. *Advanced Expert*. Harlow: Pearson Education Limited, 2014-

GaBany, R. Jay. “A Singular place”. *Cosmography*.

<https://www.cosmotography.com/images/supermassive_blackholes_drive_galaxy_evolution.html>

Mann, Malcolm and Steve Taylore-Knowles. *Destination B1: Grammar and Vocabulary.* Macmillan, 2014.