HARVARD SPEECH
Black Holes: From Newton to Einstein
Soborno Isaac Bari

GREETINGS
I am honored to be at Harvard University, and to be hosted by Harvard College Project for Asian and International Relations.

For nearly 400 years, Harvard has stood as the most prestigious university in the world. It has become a source of American enlightenment by producing many great minds, including 161 Nobel Laureates, 8 American Presidents, 130 Pulitzer Prize winners and a source of global advancement by achieving medical feats ranging from spreading the smallpox vaccine into the New World in 1799 to cracking the code of HIV in 2019, as well as scientific discoveries including black holes, which is the topic of my talk. Harvard also produced many thinkers such as Amartya Sen, who came from Asia just like my parents. As you may know, I have a long relationship with the world's most prestigious university that extends back to 2016.

At 4 years old, I received recognition from one of the most famous Harvard alumni, President Barack Obama, which made me overjoyed, considering the prestige of Harvard. That recognition created a ripple effect around the globe, which may have influenced Harvard President Drew Faust to recognize my achievements in math and science in 2018.

I was born and raised in a Muslim family. I am giving this speech at a time when Muslims and Americans have many grudges in their relationships. Recently, this tension between the United States and the Muslim world has escalated by the rise of the Taliban and their takeover of Afghanistan. I have come here to inspire not only the audience, but every single child, especially Afghan children, to fall in love with math and science. Once they fall in love with math and science, they will solve problems using chalks instead of guns. This is why I have decided to run for the President of the United States in 2048. As President of the United States, I will inspire children -- especially Muslim children -- to change the world the way Newton and Einstein did. That’s why I’m giving this speech -- in a hope to inspire children to put down guns and pick up chalks.

On my second birthday, I was inspired by my father to fall in love with math and science. Having the right parents is much like winning the lottery -- if you have parents that teach you to kill for justice in the Quran, you will become a terrorist and a tyrant. If your parents teach you to rob and steal and cheat, you’ll be a criminal. If, however, you win the lottery, you’ll have parents who teach you to fall in love with math and science. As a result, you will become -- not a terrorist -- but a scientist, one who changes the world for the better, not worse. That’s exactly what my father taught me, and I have experienced the benefits firsthand. It all started with my second

birthday. I asked my dad for a present. I didn't want money, or toys, or games. I wanted a challenge, because I was bored of the typical candles and cake. I wanted something new. Something that would change my life. And my father satisfied the request. The next thing I remembered was my father taking me to the garage as soon as I got out of bed, where there was a book lying on the floor and some instructions on a blackboard that was hung up on the wall. "You have one hour to find the name of the book and its author. Begin."

The challenge seemed ridiculous. Did it not say the title of the book on the spine and the cover? Did my father think I was illiterate? I smiled as I realized how easy the challenge was. But as I walked closer to the book, I could see no cover, and there was no spine -- just a ragtag bundle of pages sewn together with a skinny white string. My confidence quickly vanished. I found myself flipping through the pages in desperation as time ran out. The pages were written in what seemed to be Latin and abstruse math equations filled nearly every page. Just as I was about to resign, I saw a page with a schematic of the earth fly by. I flipped back to the drawing and examined it. On top of the earth was what seemed to be a cannon, firing cannonballs. Ball after ball fell back to the earth, but finally -- one ball was shot with sufficient velocity to start orbiting the earth. All of a sudden, I remembered watching a video explaining how Sir Isaac Newton discovered

I will plant a dream in the mind of every child, especially Muslim children, not to join the Taliban, but to fall in love with math and science so that they dream to become the next Newton and Einstein. Speaking of Newton and Einstein, let us dive into their most famous discoveries, gravity. Newton discovered gravity in 1665 and wrote the universal law of gravitation, which allowed us to predict the path of heavenly bodies like the sun or the moon. But even though Newton's laws held up for centuries, Newton had no idea why Gravity actually worked. We needed another brilliant mind, Albert Einstein, to help formulate the Special and General Theory of Relativity. The result of General Relativity were the field equations, which predicted the existence of a strange celestial body known as "black holes".
gravity by asking a simple question: If an apple falls, does the moon fall? Eureka! Eureka! The author must be Sir Isaac Newton! But what about the book? The clock kept ticking.

After much contemplation, I finally settled on the book's title -- "Newton's Cannonball". Just in time. There were just 60 seconds remaining. I quickly scribbled:

The author is Sir Isaac Newton.
The name of the book is Newton's Cannonball.

I don't know how, but I was extremely confident that this was the right answer. But of course, I later realized that I was wrong. The name of the book was Philosophiæ Naturalis Principia Mathematica. Regardless of that mistake, on that day, I fell in love with math and science, especially physics. From that day, I wanted to change the world just like Sir Isaac Newton and Einstein. But after that birthday, I didn't just become motivated to study physics. I realized it was

my obligation to give every single child the same opportunity I had -- the opportunity to be captivated and inspired by math and physics, not guns and bullets.

As you know, black holes were predicted by relativity. And we know that they are true due to contributions made by Harvard. The Harvard & Smithsonian Center for Astrophysics captured the first image of a black hole in 2019, but for many of us, black holes are still shrouded in mystery. My goal today is to help the crowds of the most prestigious university in the world understand gravity & black holes, and to do that, we look at it from a Narrative Perspective. I will be using the stories and discoveries of 4 scientists as a bridge to relativity and thus to black holes, from Newton to Einstein and everything in between. I will be talking about many scientists, so I want to get started with what should be at least a half-familiar story to distinguished college students like you. It was the year of 1905. Einstein was sitting at his patent office in Bern, Switzerland, as he had been doing since his application to be a technical expert was accepted in 1902. In 1905, he had published 4 papers, and one of them was on special relativity. However, his ideas weren't accepted very widely. They were actually passed off by the general public as insanity. People were like, "Hey! What is this garbage you're spewing? This isn't Newton's theory!" Two Nobel Laureates in Physics who were Nazi aligned even attacked Einstein with a racist thesis. His theories that time, distance, speed, mass, almost everything was relative, were toppling the throne that Newton had held for so long. And people objected from nearly everywhere, because Einstein's theory had supposedly been disproven with faulty experiments, including one to refute the relativity velocity dependent mass effect. But before I go in-depth about how Einstein revolutionized physics, I must talk about how Newton paved the way. Because he was the main reason I fell in love with math and physics.

Sir Isaac Newton was born to a single mother; who would've been his father, a rich, wealthy, uneducated farmer named Isaac Newton Sr. had died 3 months earlier, and his mother, who died in 1679, gave Newton to his maternal grandparents when Newton was 3. A strange fact is that his mother, Hannah Ayscough, reportedly said that baby Newton was so small he could fit in a quart mug. Newton heavily disliked his stepfather. He distinguished himself from others by building sundials and model windmills. His mother, whose husband had died again, attempted to make him a farmer, something he hated. When Newton was 22, there was a pandemic just like the coronavirus: the great plague of London. In 1665, during the plague, while he was sitting next to an apple tree, an apple fell right next to him. He thought that if an apple could fall, could the moon fall? If the apple could fall, then why wouldn't the moon fall? Was it some special thing? But Newton refused to use a thesis of theology. Even if the best English poet wrote the best piece of art about this place, Newton refused to believe that the moon was any different than the apple. And I'm sorry to all the poets that will be bankrupted by this speech. He had to invent calculus just to prove that there is no difference between the apple and the moon, and then make every single poet cry. The moon constantly falls, it just never hits the Earth. Gravity keeps it

from going away from the Earth, and the velocity of the moon, just in the goldilocks zone for orbitals, is just about high enough to keep it from falling into the Earth or escaping into space. What was gravity? Newton didn't exactly know, but he had equations for it. It was defined by $F_g = \frac{GMm}{r^2}$The theory fit perfectly with all the measurements of 1700 scientists, and so it was widely accepted. In 1750, other investigators like Bernoulli found out that electrical attraction decreases as two objects get far away in a fashion similar to gravitational attraction. In the early 1770s, a physicist named Henry Cavendish wrote $F_e = \frac{KQq}{r^2}$, which really just means the same thing as that other equation, except that now you have two electrically charged particles instead of masses, so the electrical attraction has been figured out. However, Cavendish never published his findings and the world only found out about his studies 100 years later, when a well known scientist named James Clerk Maxwell (whom we talk about later) published them in 1879. Then, in 1785, Coulomb plagiarized this equation and published it. Now I know that some of you are probably thinking that Coulomb's a plagiarist. But I would disagree, because he started the next biggest revolution: the electric revolution. However, just like in all the ancient wars, the English outsmarted the French, this time not in the battlefield, but in the electric field. And the victor was Faraday. But before we talk about the English, let us talk about a Danish scientist who paved the way: Hans Ørsted.

FARADAY

One day, Hans Ørsted left his compass near a wire in his classroom. But when he turned the current on to demonstrate Ampere's law, he noticed his compass suddenly deflecting. He dismissed class immediately, got a few other compasses, and placed them along the axis of the wire. And suddenly, they all started pointing in a certain direction. Ørsted grabbed a pen and sketched out the magnetic field that the compasses might be indicating. It was a circular magnetic field around the current-carrying wire! Ørsted had just discovered that electricity creates magnetism! Eureka! So now the world knows: electric and magnetic fields can both be generated by a current carrying wire. But electricity and magnetism were still disparate, and despite the many reasons that these two could be connected, it was thought that that theory was rubbish. But one young and aspiring, yet poor student was determined to change that. His name was Michael Faraday.

Michael Faraday was illiterate and poor until he was 14, where he learned how to read and write from a Sunday church school. Still, he was poor, and his education was essentially nonexistent. He applied for Sir Humphrey Davy's chemistry class, one of the best classes of the time. And he was accepted! An incredible step for the young man. He applied to work under the mentorship of Sir Davy, and was accepted once again! Now, having a more thorough knowledge in chemistry than almost everyone in the world, he was able to experiment with anything he wanted. One day, he wrapped two copper coils around an iron ring. And when he moved the magnet through the coil, it generated a spark of electricity. How did this happen? Well, first, an electromotive force

was generated, then, that potential difference generated current, then the current generated magnetic field, and the magnetic field generated an electric field. You can try it! First, get a copper coil, then, take two wires and attach them to the coil, then plug the other side in a galvanometer or ammeter, and move a magnet inside. The blade should move. Keep in mind that for small scale experiments trying to light up a lightbulb with this will not work because only small amounts of current are generated. Otherwise, the galvanometer/ammeter would freak out due to the high electric field. That was Faraday's great discovery. But Faraday could not translate his discoveries into mathematics. That would be Maxwell's job.

James Clerk Maxwell translated Faraday's discoveries into 4 grand equations that not only unified two of the largest subjects in physics: electricity and magnetism, but also predicted the speed of light and that light is an electromagnetic phenomena. They are stated as follows:

1. Maxwell Equation 1, in layman's terms, states that the electric field flux is proportional to the enclosed net charge.
2. Maxwell Equation 2 is easy. It just signifies that there are no magnetic monopoles, which is a consequence of the magnetic flux of a closed surface always being 0.
3. Maxwell Equation 3 is Faraday's Law in mathematical form. It essentially states that a changing magnetic field can produce electric fields.
4. Maxwell Equation 4 is Ampere's Law, which states that the total magnetic field over a closed loop is equal to the current traveling through that loop times a constant, plus the change in electric flux over time, symbolizing that electricity can generate a magnetic field.

These equations paved the way for Einstein's theory of relativity. He himself said he was inspired by Maxwell. But before we talk about relativity, we must talk about the basics: reference frames.

Speed is relative, not absolute. Say you're biking at 15 mph on a perfectly smooth, empty road, at least to someone on the street. But to you, you think you're at rest and the street man is traveling at -15 mph. And suddenly a car zips past. To the street man, the car's at 30 mph, but you see the car is traveling at 15 mph. This is because speed is relative. 30 - 15 = 15 mph, that's why the car seems to be at 15 mph. So speed is relative. And we can't tell if we're moving or not if we have a constant velocity (acceleration doesn't count). But when we go at high speeds, something more happens. It seems like time gets longer? Length gets smaller? What happens when we go too fast?

Now we talk about 3 things that happen when you go at insane speeds: time dilation, length contraction, and mass dilation. First, time dilation. Say you have a spaceship traveling at the speed of light with a laser and a mirror inside. The laser goes to hit the mirror and then comes

back. But since the spaceship is moving horizontally with the laser's vertical movement, to an observer on Earth, the light must take a longer path, thus taking a longer time to travel. But for a guy on the spaceship, he can eliminate the horizontal motion, since he is moving horizontally as well. But that means for him, light takes a shorter path, thus for him it takes light less time to travel than for the Earth observer. But this also happens with length. Velocity of light does not change, even at unreal speeds. So length, or distance must change. There is also the idea presented in general relativity where gravity is no longer some mysterious force, but a distortion in spacetime, like if you had a hammock strained to 4 sticks and placed some small beads, they would create a tiny pit that would drag anything really close in, but if you had something unimaginably massive, it would create a much bigger pit, and attract all the other beads. But some gravitational fields can be unimaginably big. This leads us to the 7th and final chapter I will mention.

Usually, spacetime is straight, only being curved by the occasional object. But black holes are like gravity wells, they curve spacetime down and down until it plunges downward due to the black hole's immense weight. To an observer outside, the objects near the black hole get extremely red shifted and time dilates until it pauses right outside the event horizon. Any objects get completely stretched and 'spaghettified' before the black hole eats them up, confirming the conspiracy theory that black holes are Italian and created by Volta. All information is lost at the singularity. i
Thank you for giving me the opportunity to talk here. Now I will take questions.

Soborno Isaac Bari is the world's youngest professor. He gave this speech on Aug 22, 2021 at Harvard University Asia Conference hosted by HPAIR. Listen this speech, Here