Please see this youtube link to view the show. Times indicated in this script go along with this video:

https://www.youtube.com/watch?v=jmyacc5EiBY&feature=youtu.be

Times are indicated for sections that have a significantly new image or sequence to go along with or when an important pause has to be made before the next section starts. Please let us know if more timing instructions would be helpful.

Thank you very much.

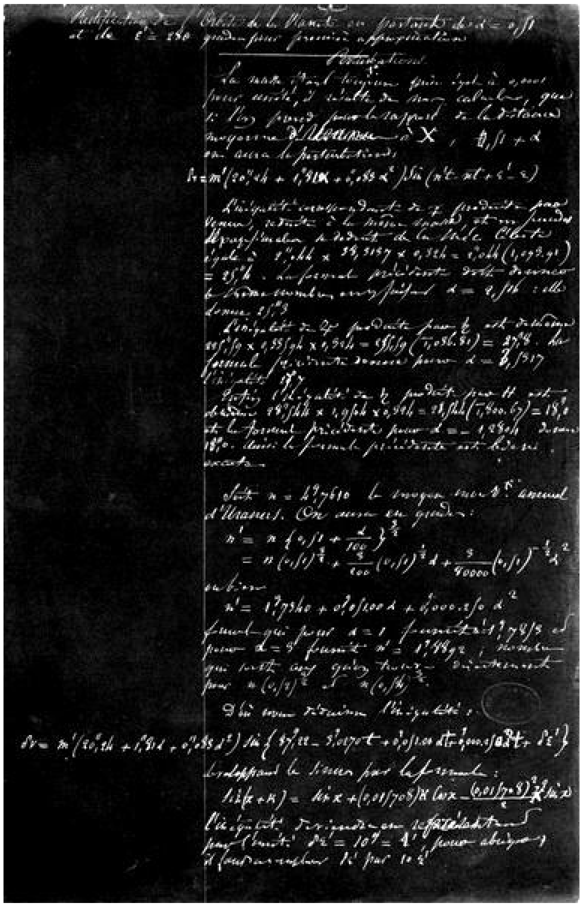
-Begin: 0:08 min-

In 1846, French mathematician Urbaun Le Verrier, carefully

1) Discovery of Neptune

Music will be played.

„Recherches sur les movement d´Uranus“, visualized on the dome.



Urbaun Le Verrier shown next.

investigated the movements of our planets.

-Begin: 0:18 min-

His attention was drawn to the orbit of Uranus. Le Verrier noticed a mysterious inconsistency between his calculations of Uranus' orbit and the actual observations. He re-checked and fine-tuned his calculations over and over again. But no matter what he did, Uranus was always in a position different than his calculations predicted.

-Begin: 0:41 min-

How could this discrepancy be explained?

Eventually, Le Verrier proposed a bold hypothesis. He predicted the existence of a yet undiscovered, eighth planet based solely on his observations of the movement of Uranus. The gravitational pull of this undiscovered planet could explain the irregularity in Uranus' orbit. This unknown planet would have to be located way beyond Uranus, far from the Sun, in the outskirts of the planetary system.

Music

Visualization of text on dome

-Begin: 1:13 min-

Le Verrier sent his calculations to the German astronomer Johann Galle. In his letter, he asked Galle to search for the so-far-undiscovered eighth planet.

Johann Galle:

-Begin: 1:29 min-

That very night, Galle pointed his telescope in the direction calculated by Le Verrier.

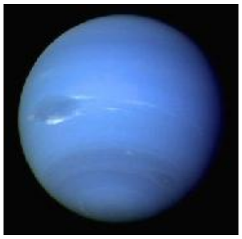
And indeed!

Galle saw a speckle of light not indicated on his stellar map.

Galle had directly observed Neptune.

The eighth planet in our solar system.

Neptune



-Begin: 1:53 min-

Precisely where Le Verrier had predicted.

What a terrific success of Le Verrier’s gravitational calculations.

Scientists continued to refine their understanding of gravity. Today, we are able to precisely calculate the motion in the universe using more modern theories such as Einstein’s theory of general relativity.

However, the depths of our universe hold an exceptional mystery.

2) Show title

3) Rotation curves of galaxies. Playground scene with a merry-go-round.

Kids' laughter

-Begin: 3:23 min

A merry-go-round.

You have to be careful not to fall off. The faster the merry-go-round turns, the tighter you have to hold on.

At its perimeter, the forces acting on your body are stronger than closer to the center.

When standing further out, you are more easily thrown off, and the merry-go-round must turn more slowly.

Video shows one child falling off of the merry-go-round.

-Begin: 3:58 min-

With a merry-go-round, we have a rather intuitive understanding of this concept. But the same holds true in the universe.

Pause.

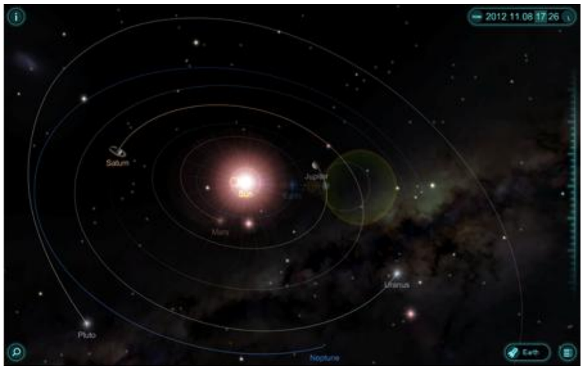
Zoom out of the children's playground.

↓

↓

↓

↓



Adaptation-/ orientation phase for viewers.

-Begin: 5:02 min-

In our solar system, all planets orbit the Sun. The exact same principle that applies to a merry-go-round also applies here. The faster the planets orbit, the stronger they must be drawn to the Sun.

It is the gravity of our Sun that pulls the planets towards it and keeps them in their orbits.

A planet further from the Sun experiences a smaller gravitational pull than one closer to the Sun. Therefore, to stay in orbit, a distant planet must move more slowly or it would be flung out of our solar system.

This is just the same as with the merry-go-round. The children standing at the edge of the merry-go-round can only maintain their position at a lower speed.

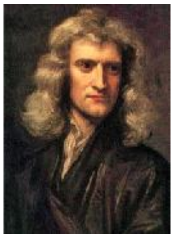
-Begin: 5:53 min-

This correlation between distance and speed was identified in the 17th century by Johannes Kepler. It is called Kepler's Laws of planetary motion.

-Begin: 6:04 min-

While the planets keep orbiting around the sun:

Johannes Kepler



Isaac Newton

Shortly thereafter, Isaac Newton was able to mathematically explain this correlation using his law of universal gravitation.

And about two hundred years later, Albert Einstein was able to fine-tune this relationship even further using his theory of general relativity.

Today, using these laws we are able to predict the motions of celestial objects such as planets,

Moons,

Comets,

Asteroids

And satellites with exceptional accuracy.

-Begin: 6:53 min-

The Earth… The Sun… Our solar system are part of a much larger structure.

Albert Einstein

Historical figures fade on dome.

Break for audience.

-Begin: 7:32 min-

The Milky Way.

Our galaxy.

The Milky Way is a spiral galaxy. Hundreds of billions of stars orbit around one common center.

-Begin: 7:55 min-

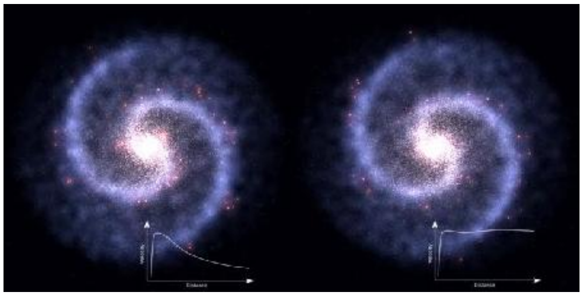
We would expect that the rotation of the Milky Way also follows Kepler’s law: the farther away stars are located from the center of the galaxy, the slower they travel.

Rotation of galaxies.

www.creationofuniverse.com

Reference speed of rotation.

Rotation curves.



Show speed of stars on dome.

But that is not the case!

Show actual speed of stars.

Instead, all stars orbit around the center with equal speed.

The speed of the stars is independent of their location from the center of the galaxy.

Enjoy the visualizations on the dome explaining this topic.

-Begin: 8:39 min-

Our Milky Way is rotating faster than Kepler’s law would allow.

How is this possible?

Pause, so that question can sink in.

-Begin: 8:51 min-

Our Milky Way is not the only galaxy to show this behavior. Every spiral galaxy rotates the same way. Their stars always travel with equal speed around the galaxy’s center.

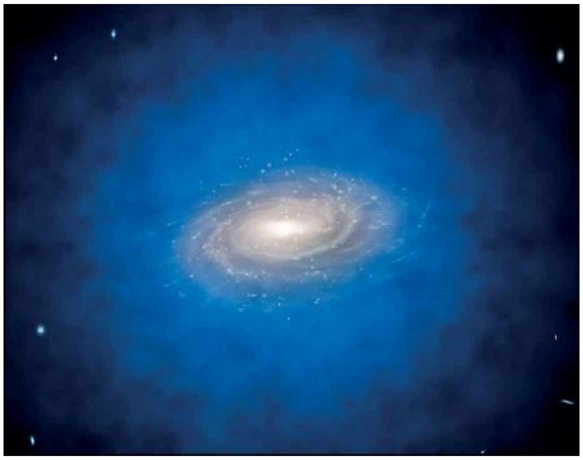
How is it that stars can move so fast without the galaxies breaking apart?

What keeps stars in their orbits?

Brief pause.

The answer is, an additional force. A kind of “glue” that holds each galaxy together.

Dark matter halo



Ghost-like animation. Dark matter as a mysterious matter.

-Begin: 9:32 min-

This is our first piece of evidence that there must be more matter in our universe than we can see. It is the gravity of this additional matter that holds galaxies together.

No matter what wavelength we look at the sky: In visible light, infrared or ultraviolet, radiowaves or X-rays, we are not able to see this additional matter. It remains concealed.

-Begin: 10:07 min-

We cannot see nor feel this matter. No detector has ever been able to observe it directly.

We therefore call it

Dark Matter.

Pause.

The gravity from dark matter is what keeps the stars in their orbits.

Dark matter acts like a glue. Its gravity keeps the galaxies together.

Pause

Galaxies are loaded with it.

In fact, galaxies contain five times more dark matter than normal matter.

Pause

We know it exists.

But we have no idea what it is made of.

4) Large Hadron Collider

CERN

-Begin: 11:15 min-

The European Center for Nuclear Research CERN in Geneva, Switzerland.

Large Hadron Collider

Home of the largest and most powerful particle accelerator in the world. The Large Hadron Collider LHC.

Immense in size, the Large Hadron Collider is a 16 miles or 27 km long, circular tunnel. It reaches from Switzerland across the border into neighboring France.

Service shaft:

-Begin: 12:06 min-

From technicians and scientists, from tools and materials, everything is brought underground through service shafts such as this one, reaching 30 stories underground.

-Begin: 12:49 min-

In this tunnel, hydrogen nuclei are accelerated nearly to the speed of light and set on a collision course. Each second, more than one billion hydrogen nuclei collide. In the extreme conditions of these collisions new particles are created.

The particle accelerator itself is only one part of the experiments being conducted at CERN. The point where the hydrogen nuclei collide is surrounded by huge detectors – each of them the size of a multi-story building.

Here we are moving through one of those detectors: The Compact Muon Solenoid, CMS.

This highly complex machine detects each newly created particle with all its properties.

The particle accelerator

-Begin: 13:47 min-

This produces a tremendous amount of data: More than one gigabyte each second.

The particles created during each collision can be identified only through elaborate analyses.

To meet this challenge, large international collaborations with more than two thousand scientists from all over the world examine this data for traces of yet undiscovered particles.

The Higgs particle was recently discovered using this method.

And similarly, scientists at the Large Hadron Collider are searching for dark matter particles in their data.

CMS-Detector

5) Colliding galaxy clusters

-Begin: 15:04 min-

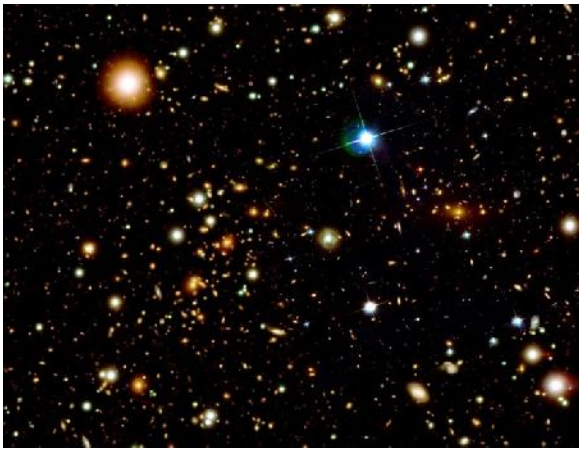
We return to outer space to continue our quest for dark matter, far away, well beyond our Milky Way.

Dome shows a virtual galaxy cluster.

Galaxies do not exist in isolation. Rather, they group together with other galaxies to form galaxy clusters.

Such galaxy clusters are found everywhere, near and far, with each cluster containing different numbers and types of galaxies.

Bullet Cluster:



-Begin: 15:39 min-

With ordinary telescopes, scientists can only see matter that radiates visible light. This is just a tiny fraction of the total matter found in galaxy clusters.

The Chandra X-ray telescope can see beyond visible light into the X-ray range of the spectrum. With this telescope, diffuse hydrogen gas becomes visible. Shown here in red, this gas fills up the space in-between galaxies and comprises significantly more mass than all shining stars combined.

Galaxy cluster and red gas.

Using a technique called gravitational lensing it can be shown that indeed, most mass is located in this diffuse gas. Gravitational lensing allows us to basically weigh galaxy clusters.

-Begin: 16:32 min-

If we examine images of galaxy clusters carefully, we can see small arcs. These are distorted images of galaxies that are located far beyond the galaxy cluster. The gravity of the galaxy cluster has bent the light from the galaxies in the background. This effect is called gravitational lensing.

-Begin: 17:00 min-

The more massive a galaxy cluster is, the more it will bend light from galaxies in the background.

Therefore, we can calculate the mass of a galaxy cluster, as well as its distribution, using the observed gravitational lensing.

Show Bullet cluster

Bullet Cluster by Chandra

-Begin: 17:19 min-

The Bullet-cluster is located in the southern sky constellation Carina. Here, two galaxy clusters passed through each other about 100 million years ago.

Begin animation of cluster collision.

Even within galaxy clusters, individual galaxies are very far apart and rarely collide. Galaxy clusters simply move through each other.

-Begin: 17:50 min-

A very different behavior is observed in the diffuse hydrogen gas within the galaxies, shown here in red from an X-ray image.

While both gas clouds collide, friction slows them down. A wake forms, easily visible in the cluster on the right. This shape gave the Bullet cluster its name.

As the hydrogen gas slows down, it lags behind the galaxies. Today, 100 million years later, we observe two clouds, separated from the galaxies.

-Begin: 18:27 min-

We would expect that most of the mass is located in those gas clouds. This can be tested with gravitational lensing.

However, this leads to a big surprise: most of the mass, highlighted here in blue is found near the galaxies.

Show gas.

-Begin 18:54 min-

There is five times more mass where the galaxies are, compared to what we can see in the form of stars and diffuse hydrogen gas together.

This invisible mass is dark matter again.

Apparently, dark matter just kept moving, without being influenced by the collision at all. It passed through itself without interacting or slowing down.

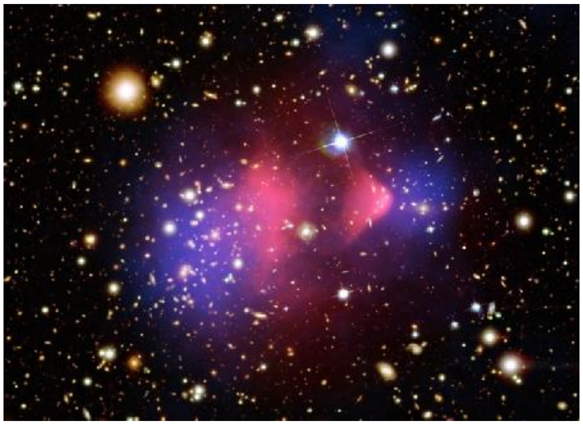
No known form of matter shows such a behavior. Dark matter has to be a completely new, unknown form of matter.

-Begin: 19:39 min-

We learned something about dark matter.

Without ever having seen it.

Animation dark matter in galaxy clusters.



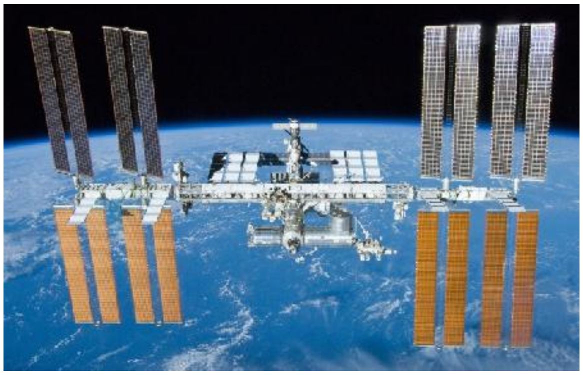
6) Alpha Magnetic Spectrometer

-Begin: 20:13 min-

About 250 miles or 400 km above Earth.

The international space station ISS. An impressive example of international collaboration. The United States, Canada, 11 European countries, Russia, and Japan built and operate the space station together.

ISS



Zoom to AMS

-Begin: 20:53 min-

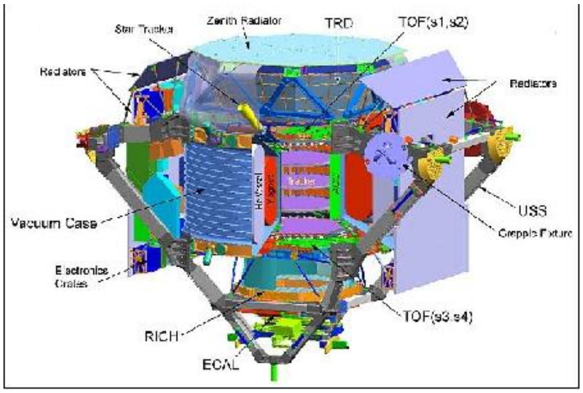
Naturally radioactive particles from outer space constantly bombard Earth. We call these particles the cosmic radiation.

Since 2011, the Alpha Magnetic Spectrometer AMS located on the International Space Station, is being used to study this radiation.

This detector is similar in complexity to the detectors located in the Large Hadron Collider at CERN, but additionally, the Alpha Magnetic Spectrometer is located in Earth orbit.

At the Large Hadron Collider at CERN, scientists attempt to create dark matter particles from collisions of hydrogen nuclei. With the Alpha Magnetic Spectrometer, in contrast, scientists attempts to search for the inverse process. They search for particles that are created when dark

Show AMS structure



matter particles collide with each other in outer space.

The main difficulty is to differentiate dark matter signals from other signals, such as those from black holes or neutron stars. This is one of many challenges scientists are currently investigating.

-Begin: 22:28 min-

The Mount Wilson observatory in California.

In the 1920s, building on the work of astronomers before him, Edwin Hubble observed the motions of galaxies.

7) Structure formation

Allsky of Edwin Hubble in his observatory.

-Begin: 22:53 min-

He made one of the most momentous discoveries of his time: the universe is expanding.

All galaxies are moving away from each other.

Night sky visible.

Fade observatory.

Fade Hubble.

-Begin: 23:13 min-

So, if we, just as a thought, turn back time…

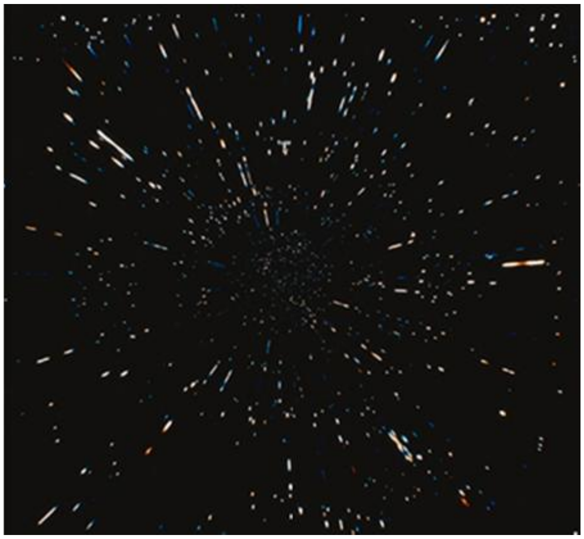
…this implies that someday in the past, the Universe was densely packed.

-Begin: 23:29 min-

We say: the Universe started with a hot big bang.

Since then, space has continuously expanded, causing the Universe to cool.

Galaxies drift away from us:



Motion of stars stops.

Music goes backwards.

More galaxies visible, more crowded.

Cross-fade to white

Slowly cross-fade onto CMB

The heat remaining from the big bang is still out there.

We call it the Cosmic Microwave Background radiation.

-Begin: 23:55 min-

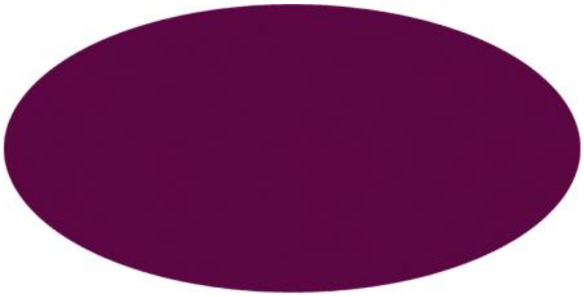
This is how the universe looked when it was only three hundred thousand years old.

Everything was exactly the same in each direction.

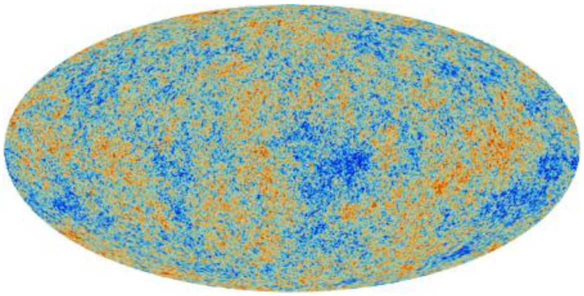
Completely void of structure.

Today, we measure this radiation with sophisticated satellites.

Color reflects the average temperature



Change colors according to this image:

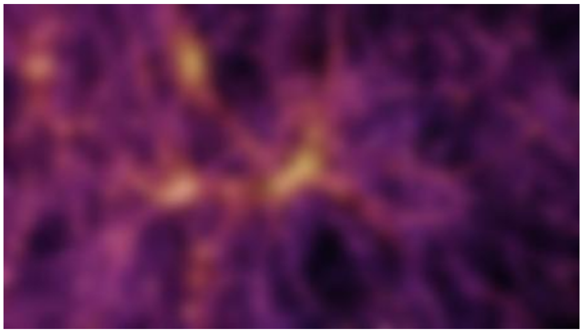


It is only by looking extremely closely at this radiation that minute temperature differences become visible.

The young universe was a rather dreary place.

In contrast, our universe today is teeming with complex structures. Galaxies. Planets. Nebulae. But how did they evolve?

Aquariums simulation



-Begin: 24:37 min-

Today, we are able to simulate this fantastic evolution with the help of supercomputers, shown here in a time lapse. The brighter an area, the higher the concentration of matter.

As a result of gravity, matter clumps together.

-Begin: 25:20 min

First, smaller structures form.

Like a magnet, the gravity of those early galaxies pulls more and more matter towards them.

The galaxies grow larger and larger.

Slowly but surely, the universe develops into its present-day configuration.

Gigantic structures, more than 100 million light years across, permeate the universe like filaments in a sponge.

Those tiny fluctuations that we observe in the Cosmic Microwave Background radiation, emitted shortly after the Big Bang, had to clump together rapidly in order to form the huge structures we observe today.

This requires an enormous amount of gravitational pull. The gravity of dark matter.

We can model the observed universe with astounding accuracy in computer simulations. These

Running animation...

simulations give the correct picture even when all they simulate is just dark matter.

-Begin: 26:16 min-

The evolution of the universe thus gives us another piece of evidence for the existence of dark matter.

We only see the stars glowing. Like lanterns, they hang on the cosmic scaffold made of dark matter.

But for the evolution of the universe, they are irrelevant.

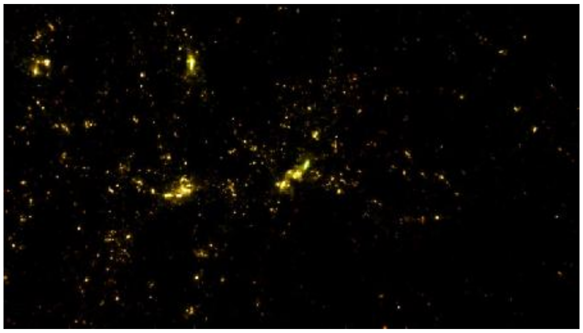
Galaxies,

Stars and their planets,

And everything that is happening on those planets,

All these incredible actors have no major role on the magnificent stage of the cosmos.

Lights are hanging at the dome like on a Christmas tree –the tree is dark matter.



8) XENON

-Begin: 27:18 min-

We are flying through the Milky Way with our spaceship Earth. In doing so, we pass through the vast amount of dark matter that fills the Milky Way.

Using sophisticated experiments, scientists are trying to capture individual particles from this head wind of dark matter.

-Begin: 28:09 min-

Assergi, Italy.

A sleepy mountain village east of Rome, located in the middle of the Italian Abruzzo mountains.

This region is not a tourist attraction. Only few will know of it,

Gran Sasso mountains

perhaps for its red wine Montepulciano d’Abruzzo, for its saffron, or its truffles.

-Begin: 28:42 min-

Or perhaps for the beautiful mountain landscape.

You would be surprised to find one of the most important research facilities engaged in the search for dark matter, far beneath the extensive hiking trails of the national park, in the heart of the Gran Sasso Mountain.

In the 1980’s, a highway tunnel more than 6 miles or 10 km long was dug into the mountain to establish a highway from Rome across Italy, to the Adriatic Sea.

Gran Sasso tunnel

This was an opportunity to build the world's largest underground laboratory: The Laboratori Nazionali del Gran Sasso.

This lab is located half-way into the tunnel, in the middle of the mountain.

-Begin: 29:58 min-

A maze of corridors,

Tunnels,

And gigantic halls.

Various experiments are located here all for the same reason: To be shielded from other environmental influences, especially from cosmic radiation. While cosmic radiation is the key signal for the Alpha Magnetic Spectrometer in space, on Earth's surface, it is an annoying source of background for these experiments. But one mile beneath the Gran Sasso mountain, hardly any of it is left.

That is why this is a great location to look for even the weakest signals from various particles.

-Begin: 30:53 min-

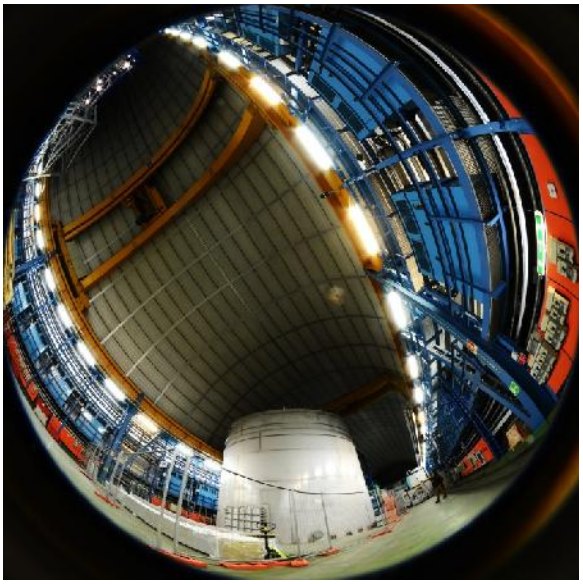
It is the perfect place for the most sensitive detector in the search for dark matter: the XENON detector.

-Begin: 31:11 min-

A water tank, 30 feet or 10 meters in diameter, screens out all kinds of natural radioactivity from the surrounding rock.

A cryostat at the center of the water tank holds liquid xenon. More than three tons of this noble element are very carefully monitored by highly sensitive cameras looking for traces of faint signals. Even single photons or single electrons generated

XENON1T in hall B



anywhere within the xenon can be detected.

The scientists involved in this experiment hope to be able to spot a glimpse of dark matter particles caught in their xenon detector.

9) End

-Begin: 32:35 min-

The structures we observe in the Universe today only formed because of vast amounts of dark matter.

Show image of structural formation again.

Gravitational lensing shows us that galaxy clusters are actually heavier than initially thought.

Show Bullet Cluster again

-Begin: 32:54 min-

And dark matter holds the rapidly rotating galaxies together.

Show galaxies rotating

These are only three examples of a long list of independent observations that all lead to the same conclusion: the universe is dominated by dark matter.

The rest… is just the cherry on top.

So we know that dark matter exists.

But what is it made of?

What is dark matter?

Pause to think.

We are in a similar situation today as once Johann Galle almost 150 years ago.

Animation of Johann Galle

Once again, gravity shows us the existence of new, yet unknown matter. But today, a variety of technologies are available to explore this cosmic secret.

-Begin: 33:57 min-

We can search for various particles that originate from dark matter, using the Alpha Magnetic Spectrometer and other telescopes.

Add AMS image.

We can try to detect dark matter particles using dedicated experiments far underground.

Show Xenon.

-Begin: 34:20 min-

And we can even attempt to produce dark matter particles in accelerator experiments.

Show LHC.

-Begin: 34:33 min-

But the question still remains: which experiment will be the first to detect dark matter particles?

-Begin: 34:45 min-

From the beginning of time

We observed the cosmos at night.

And from the beginning of time we suspected,

That the universe was teeming with unknown wonders.

Today

We look at the starry night.

And for the first time in our history we know,

That the universe is commanded by unseen matter.

It is up to us,

To answer this challenge.

It is time,

To be curious.

-End: 35:20 min-

Night sky

Come back to the merry-go-round.

Wrap up the program with the same entrance music we had.

10) End titles

tbd.