Lisa Pathfinder - Window on the Gravitational Universe

INTRO WEB

LISA Pathfinder’s name, Laser Interferometer Space Antenna, clearly indicates the role of precursor that this mission plays. Its goal is to validate the technology required to detect gravitational waves from space. Gravitational waves will open a new door in our understanding of the Universe, and at the same time help to verify Einstein’s General Theory of Relativity. LISA Pathfinder will be launched at the end of November on a Vega rocket from Kourou in French Guiana.

10:00:10

VO: Esa’s mission LISA Pathfinder will take us one step closer to being able to directly check the arguably most famous scientific theory posed, Albert Einstein’s theory of General Relativity. One of the predictions of this theory are gravitational waves: the Universe’s mechanism for transmitting information about the weakest of the fundamental forces, gravity. LISA Pathfinder will test the extremely precise technology required to measure these waves, and thereby is the first step in opening a new window into the Gravitational Universe. So much of the science and technology around us today is based on how gravity, the fundamental force of our universe, works, but the gravitational waves of Einstein’s theory have never been directly detected.

What makes these detections so difficult is that the effect of the passage of a gravitational wave is so subtle, that it requires an incredibly large and sensitive detector to measure them.

*Images - Animation LPF launch sequence 31/08/2015, ESA/ATG medialab, Still Einstein in front of blackboard, unknown date - internet, animation of model of gravitational wave ESA 01/09/2015 , LISA Pathfinder (main spacecraft and propulsion module in IABG cleanroom, Ottobrunn, Germany – 03/06/2015 - ESA – ESA, people working in lab on Optical benches July 2015 Albert at Einstein Institute, Hannover, Germany, - fly through galaxy animation with effect ESA, Quasar animation from Integral ESA 2012.*

10:01:13

**ITW: Paul McNamara, LPF Project Scientist ESA**

**The General theory of relativity predicts what we expect to see from gravitational waves in terms of the ripples in space time and for a very large signal, that would be two galaxies merging, the super massive black holes at the centre of a galaxy really crashing together, and then we have to measure pico metres, one pico metre being changes roughly one hundredth the size of an atom , this is very difficult and its not believed its even possible.**

*Image - Supernova animation NASA Goddard SVS*

10:01:36

VO: These measurements are only possible with a very large detector like this one here. Called GEO600 it has two 600 metre long laser arms housed in vacuum tubes that run at right angles to each other along fields just south of Hannover, Germany. A gravitational wave of sufficient amplitude would make the two beams go out of phase by a tiny but measurable amount. By recording this phase change, scientists can determine the properties of the gravitational wave signature, and hence the astrophysics of the celestial body which produced the waves. However, so far gravitational waves have not been directly detected.

*Images – GEO600 images, Albert Einstein Institute Germany Hannover, Germany july 2015, Virgule black hole animation, back to GE0600 then animation of black hole.*

10:02:16

**ITW: Karsten Danzmann, Director, Albert Einstein Institute Hannover**

**So far we haven’t seen anything but any minute now a star could explode and then we could see a signal”**

10:02:23

VO: The difficulty of measuring gravitational waves from ground based detectors is that the major astronomical events, which are observable from Earth, are rare and when they do happen the distortion created by the earth itself can mask the signal. This has driven the desire for a lower frequency space-based detector, where the signals are plentiful and the detector is free from Earth induced noise.

*Images- Animation of quasars, ESA Hubble Space-telescope, Still of Earth's protective shield 06/02/2014, Image of LPF fly-by leaving Earth and in orbit from Animation LPF launch sequence 31/08/2015, both ESA/ATG medialab,,*

10:02:49

**ITW: Paul Mc Namara,**

**Gravitational waves are ripples in the fabric of space-time, in order to measure these ripples we have to build Detectors which are only susceptible to this gravity of space so we have to remove all the other forces, like thermal forces solar radiation pressure, magnetic forces.**

10:03:04

VO: So LISA Pathfinder will be sent to a stable orbit, 1.5 million kilometres from earth towards the sun, known as the 1st Sun-Earth Lagrange point. However, another problem is how to avoid distortion to the measurements of this incredibly precise but sensitive detector from the engine and workings of the spacecraft itself.

*Images – Lagrange point diagram, and LPF engine – Lisa pathfinder animation, build up of LISA pathfinder – June 2015 - ESA*

10:03:27

**ITW: Paul Mc Namara–**

**The spacecraft itself has a bigger effect than what were trying to measure, so the real challenge of gravitational wave measurements and Lisa Pathfinder are how to build a spacecraft that isolates the test mass from everything else.**

10:03:39

VO: The test masses in the case of LISA Pathfinder are 2 solid gold-platinum cubes that float in near-perfect gravitational free fall, enveloped and protected within the heart of the spacecraft, their tiniest movements being measured and relayed back to us here on earth.

LISA Pathfinder is a pure technological experiment to show whether it is possible to create a detector in space of such sensitivity and accuracy that it can measure these waves that are passing through us all the time without us consciously noticing them. After the successful demonstration of the technology, ESA plans a much bigger mission, involving three spacecraft flying in formation, linked by lasers.

*Images – Lisa pathfinder animation, build up of LISA pathfinder – June 2015 - ESA, Then images of spacecraft in formation from eLisa mission animation from "MPI for Gravitational Physics/Milde Marketing/exozet”.*

10:04:23

**ITW: Paul McNamara,**

**After we do LPF, we then take effectively two or three LPF spacecraft, we separate them by 5 million kilometres, we have one cube in each spacecraft, and we measure the distance between the cubes. So the Lisa pathfinder mission was instigated by ESA to test if we can ever make the measurement, and as of today we believe we can do it.**

*Images- eLISA animation of 3 Lisa spacecraft in formation "MPI for Gravitational Physics/Milde Marketing/exozet”*

10:04:43

VO: LISA Pathfinder isn’t just about proving Einstein’s theory, 100 years after it was first proposed; the very precise technology developed for this mission and the ability to detect gravitational waves can potentially open up a new and yet unobserved dimension of our universe.

*Images -Animation of Einstein from "MPI for Gravitational Physics/Milde Marketing/exozet”and image of exploded star.*

**10:05:01 - End of A-Roll and beginning of B-Roll**

ITW - Interview Paul McNamera, IABG cleanroom, Ottobrunn, Germany – 03/06/2015- ESA

*Why ?*

«So gravitational waves were first predicted round about 100 years ago as a consequence of a general theory of relativity, and 100 years after General relativity was first published were now launching Lisa pathfinder which goes a very long way to testing relativity in the most extreme environment.

Gravitational waves are very important because we can really look back to the time of re-ionisation, we’re looking back to about 4 hundred million years after the big bang. and then we’re looking at the first stars, we’re looking at how the universe has evolves from the very earliest times to where we are today, we’re looking at how the gravity is affecting galaxies, andin essence what we’re doing is we’re measuring General Relativity in the really extreme events of the universe

**10:05:52**

ITW - Interview Paul McNamera, IABG cleanroom, Ottobrunn, Germany – 03/06/2015- ESA

*Sifting out other forces*

Gravitational waves are ripples in the fabric of space-time, in order to measure these ripples we have to build a Detector which are only susceptible to this gravity of space so we have to remove all the other forces, like thermal forces solar radiation pressure, magnetic forces, and when we can do that we isolate the spacecraft and then we measure this between them, this is very difficult and ESA took the step to adopt the Lisa Pathfinder mission, which is essentially a proof of principle of how you can make this measurement of Space-time

**10:06:34**

ITW - Interview Paul McNamera, IABG cleanroom, Ottobrunn, Germany – 03/06/2015- ESA

*Isolating test mass.*

So one of the biggest problems of studying gravitational waves are the spacecraft themselves so we want to isolate our test masses or bodies, however we have to find them a spacecraft because we have to communicate with earth, we have to get there but the spacecraft itself has a bigger affect than what were trying to measure 05:04 so the real challenge of gravitational wave measurements and Lisa Pathfinder are how to build a spacecraft that isolates the test mass from everything else

**10:07:08**

ITW - Interview Paul McNamera, IABG cleanroom, Ottobrunn, Germany – 03/06/2015- ESA

*Difficulties of measuring gravity*

So the General theory of relativity predicts what we expect to see from gravitational waves in terms of the ripples in space time and for a very large signal, that would be 2 galaxies merging, the super massive black holes at the centre of a galaxy really crashing together, we expect to see a signal/cut/ round about a part of a 10th minus 21 of the length of our detector, if we take a 1 metre detector we have to measure changes in the length of that detector round about a part to a thousandth of the size of an electron, that’s impossible, so what we do is we take our detector and we make it exstreamly long, in tens of millions of kilometres, and we have to measure pico metres, one pico metre being changes roughly one hundredth the size of an atom , this is very difficult and its not believed its even possible, so the Lisa pathfinder mission was instigated by ESA to test if we can ever make the measurement, and as of today we believe we can do it

**10:08:10**

ITW - Karsten Danzmann, Director, Albert Einstein Institute Hannover, Germany july 2015

"So far we haven’t seen anything, but any minute now a star could explode, and then we could see a signal."

**10:09:54**

LISA Pathfinder Clean Room images, 3 June 2015 IABG, Munch, Germany,

**10:15:25**

Animation LPF launch sequence 31/08/2015, ESA/ATG medialab