Introduction

Good morning x3
I'm ……. from …….. and today I'm going to take you on a trip through our Milky Way.

Today we're going to be part of a very special event that is happening in 31 schools in 11 countries across Europe, all at the same time.

The reason we're doing this is because of the recent launch of Gaia, a wonderful new satellite. This satellite is going to map the position (and speed) of over a billion stars in our Galaxy.

This morning we are going to:

Look at our place in space
Find out about the Gaia mission
Connect live to the European Space Operations Centre in Darmstadt Germany

But I can't do this alone, to get through this journey I'm going to need [point to random people in audience] space explorers, math whizzes, future astrophysicists, and rocket scientists! Together, we're going to look at how Gaia is opening the eyes of scientists to give a clear view of our very own galaxy.

However, I don't need people with me on this trip who shout out when I ask a question or need volunteers. I need people who will reach for the stars, and put their hands in the air.

Are you ready? …. Come on, I said are you ready? Now show me some of that space explorer energy, are you ready?!
Great, let's start with a question. Who can tell me what this is on the screen behind me?

[Put picture of Sun]

That's fantastic, well done! This is the kind of person we need for our trip. Give him/her a round of applause!

Our place in space

Ok, I have some more easy questions for you to start with

[Go through these as quickly as possible]

When do we see the Sun?
When do we see the stars?
Can we see any stars in the day?
Can we see any of the stars we see at night in the day?
Why not, where have they gone?

They haven't gone anywhere. We can't see them because their light is blocked-out by the Sun. [*Optional demo: Sun blocks out the stars, see Appendix 1*]. The Earth is always completely surrounded by stars.

If the Sun manages to block out the light from all the stars we see at night, that must mean that it is the biggest and brightest type of star?

- Put your hands up if you think the Sun is a really big type of star?
- Who thinks it is a really small star?
- Who thinks it is a normal average sized star?

The Sun is a normal average sized star. There are stars out there in space that are bigger than the Sun and some that are smaller. So why does the Sun loos so big and bright? Yes, that's right because it is closer to us.

[*Optional demo: Apparent size, see Appendix 2*]

At night, can we see ALL of the stars (except for the Sun)?

Lets' see how that works.

[Demo: The Earth spins and orbits the Sun; seeing different stars at different times of the year]

For this I need 4 volunteers, so who wants to be the Sun?

Excellent, please come up and join me. (Give them a round of applause). [Ask volunteers name] We have [volunteers name] who is going to be the Sun. They are going to stand in the middle [direct volunteer to correct position.

So, who wants to be the Earth? [Can be easier and make the demonstration faster if presenter/explainer holds the Earth globe rather than a volunteer, would also mean let interruptions to the flow of the explanation]

That's great, please come up and join me. (Give them a round of applause). [Ask volunteers name], this is [volunteers name] they will are the Earth [give volunteer Earth globe and direct them to the correct position, fairly close to the Sun on one side].

I also need 2 people to be stars? Thank you, please come up and join us. (Give them a round of applause). [Ask volunteers names] We have [volunteer 1 name] and [volunteer 2 name] they are going to be stars and stand either side of the Sun [direct both stars to the correct position].

We're in [country or city/town] which is here [show in Earth globe and stick small object/figurine in position].

When it is daytime for us in [country or city/town], the Earth is facing towards the Sun. We can't see [name of volunteer 1 that is standing in same direction of Sun] star as their beautiful bright light is being blocked out by the Sun.

You all know that the Earth spins or rotates (on its axis) making it night and day [make sure that the volunteer holding the Earth spins the globe around to demonstrate this] How long does it take to spin all the way round once / make one full rotation? That's right 24 hours or 1 day.

[Could add in here that to us here on Earth it looks as if it is the Sun that is moving;

it appears to rise in the east each morning and set in the west each evening. For the same reason the stars also appear to move across the night sky; rising in the east and setting in the west].

So, the Earth rotates and when [name of country or town/city] is facing away from the Sun it's night [make sure volunteer holding globe stops it spinning]. From this position we still can't see [name of volunteer 1] star, but we can see [name of volunteer 2] star.

So, how can we get to see [name of volunteer 1] star? Yes, the Earth moves around or orbits the Sun. How long does it take for the Earth to make a complete circle or orbit? That's right, 365 days or 1 year. So, when the Earth moves half way around the Sun we can see [name of volunteer 1] star at nighttime, and we can't see [name of volunteer 2] star as their light is now block out by the Sun.

Let's say that in January [or ask volunteer 1 which month their birthday is in], at night, we can see [name of volunteer 1] star. The Earth then moves half way around the Sun, from winter to summer [or appropriate season if asking month of birthday]. Then in June at night we can see [name of volunteer 2] star.

At night, can we see ALL of the stars (except for the Sun)? No we can't there are some stars that we can only see at certain times of the Year. The Earth is complete surrounded by stars, therefore, considering our model again, if there was a star up towards the ceiling, when would we be able to see it from [country]? We could see it every clear night of the year. If you wanted to see as many stars as possible you would have to watch the sky as it changes through the night and over the course of a year.

The Solar System (difference between planets and stars)

The Earth is one of 8 planets that orbit the Sun.

Who can tell me something that's different between a star and a planet? Those were some great answers.

There are two main differences between stars (like the Sun) and planets. Star emits light, and planets don't; and planets orbit around stars.

(The reason we can see other planets in our Solar System is because they reflect the light from the Sun).

[Demo: Sorting the Solar System]

To demonstrate how the planets orbit the Sun, we're going to play a little game. To play this game I'm going to need 12 volunteers.

First of all, I need a Sun! Which one of you very bright, and would like to shine on stage as our Sun? Yes you, you look positively radiant, come up here and stand over there for me. Now I'm going to give you this hat, that identifies you as our Sun. Put this on your head, and then everyone can tell what you are.

I also need 8 planets. Our planets are named after Roman gods, so if you'd like to be a planet, then show me your Roman godly faces. You there, come up and stand next to our Sun. [Pick your 8 planets and get them to form a line next to the Sun then go stand behind the planets].

Planets, turn around and face me. I'm going to give you all a hat, with a planet on it, which you'll put on your head. It is very important that you don't look at the hat, and don't turn around! [Pass out hats while repeating last two instructions].

Wait like this until I tell you to turn around.

Now, I need three astronomers. [Pick the astronomers].

I'm afraid I've mixed the planets up, and they need to be put back into the correct order. Our astronomers will have a race against time to put them in the right place. To do this, they can shout, they can direct, and they can point, but they cannot leave this spot. You may not touch the planets. Don't forget to ask the audience for help too.

In a moment we will count down from three, and at three, our planets will turn around, and your time will begin. You will have exactly 20 second to get the planets in the right order. Are you ready astronomers? Are you ready planets? (Hold up fingers to get crowd to count down). It's a 1, it's a 2, it's a 3, turn around!

[Give a warning with 5 seconds to go]

Fantastic, that's really good. You sorted out our Solar System. Let's give these clever astronomers a hand. Just so we never forget, let's go over the order of the planets all together [ask them to shout out names of planets].

Closest to the Sun we have …… [and so on]. Fantastic, let's have a huge round of applause for our planets and the Sun. Astronomers, go back to your seats. Planets and Sun, give me your hats and off you go as well.

So we now know that there are 8 planets orbiting our Sun. And that these planets spin while they orbit the Sun. We also know that the Sun is a star which is different from a planet, and there are many other stars in our galaxy.

[For a small group of students (20-30) an alternative might be to use the planets cards. Split into smaller groups of 5 maximum, give each group a set of planets cards, order mixed up and face down. The groups will race to sort the Solar System the fastest.]

The Milky Way galaxy

All the stars that we can see at night belong to our Galaxy. Can anyone tell me the name of our Galaxy? That's right, it is called the Milky Way.

A galaxy is like a giant city of stars, which typically has the shape of two fried eggs stuck together back-to-back. [Show picture on screen and point out different parts]. There is a bulge in the centre, and a disk around the edge. Galaxies come in all sorts of shapes and sizes [show various pictures of different galaxies. Let's have a look at our galaxy, the Milky Way.

In the Milky Way galaxy the Sun is just one of about 100 billion stars and is about 26,000 light years *[give distance in kilometers?]* from the centre.

The Milky Way is similar to other galaxies with a central bulge and a disk that is in a spiral shape. However, we can't travel outside of the Milky Way to find out exactly what it looks shape it is and exactly what it looks like, all we can do is study it from the inside.

Astronomers know that the Milky Way has spiral arms but do not know exactly how many there are. This is an artist's impression of what the Milky Way is thought to look like [Show commonly used artist impression of what the Milky Way looks like – e.g. https://solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=8083]

Measuring distances in space - parallax

(Earlier on we said that) the stars that we see at night are similar to the Sun and look smaller because they are further away. But just how far away are they?

After the Sun (149,600,000 km), the next nearest star to us is called Proxima Centuri. It might be the next closest star but light from this star takes about four and a half years to travel to us. Light is the fastest thing we know and travels an incredible 300 thousand kilometers in just one second. If we could travel there in a rocket it would take about 70 thousand years!!! That's just the nearest star. Other stars are thousands of times further away than that.

Measuring the distance to the stars - Parallax

How can we measure the distance to the stars? We can't use a giant tape measure/ruler. One way is to use something called the Parallax. Let's have a look at how the Parallax works.

Everyone hold out one arm, make a fist and stick your thumb up. Make sure that you hold your thumb up so you're not looking at the back of someone's head.

Look at your thumb and close one eye at a time. What do you see happening? Yes, as you close one eye at a time you thumb appears to move against the background.

This is the idea of Parallax.

The Gaia mission will use the concept of the parallax to accurately work out the distance to 1 billion stars in our Galaxy. In addition to working out their position and how they are moving (everything in space is moving – even the galaxy is rotating).

The Gaia mission in brief

I think it's time now that we found out more about the Gaia mission.

Gaia is an astronomy mission from the European Space Agency or, ESA. ESA was started in 1975 and is made up of 20 countries. Most of these countries are too small to take part in big space projects on their own. By working together as a team, they can play an important part in many different space activities.

The Gaia mission is one of these, it is an astronomy mission that was launched on 19 December 2013. As we just said Gaia will measure the distance of one billion stars in the Milky Way. It will take 5 years to do this and provide a huge set of new information about our Galaxy which will help astronomers to better understand how the Milky Way formed and how it has changed over time.

As well as this Gaia will look for alien worlds orbiting around distant stars and be able to see when giant stars coming to the end of their lives begin to explode dramatically. In addition, Gaia will look for asteroids in our Solar System roaming close to Earth.

In a few minutes we are going to link live to the European Space Operations Centre [ESOC] in Germany to find out more about the mission from European Space Agency experts.

First let's have a look at how the spacecraft was prepared for launch. Here I've shown you an artist's drawing of the spacecraft, let's watch a video to see what it actually looks like.

Video: Preparing the satellite and launch (time-lapse) [Duration 2 minutes 9 seconds]

So, Gaia was successfully launched on 19 December 2013, it then spent the next few weeks travelling 1.5 million km to a special orbit known as L2.

Video: Gaia journey to orbit [duration 1 minutes 39 seconds]

This special orbit means that Gaia has a clearer view of the cosmos than it would if it was orbiting around the Earth. At this orbit, Gaia's solar panels that power the spacecraft are always facing towards the Sun and its sensitive telescopes, detecting faint light from distant stars are always facing away from the Sun so preventing the Sun's heat and bright light from spoiling the view.

Introduction to 'live' link up to ESOC

In just a minute or two we will link up to the European Space Operations Centre, in Darmstadt, Germany, where the Gaia spacecraft is being controlled from. There you will be introduced to two ESA experts who will tell us more about the mission, how it works and what it will do.

10:50 – Go to live link-up

[Project translated answers to questions, provide additional verbal translation if necessary and possible. During second segment Q&A ask if the students have any more questions and send them to ESOC via the web chat]

11:25 – conclusion from ESOC and handover to school

[Give brief recap of live content and explain what you will do for the final section of the mornings events]

[The structure of the last half an hour – teachers to be consulted on how much time will be available after the live segment and what sort of activities/ content this could include. A few suggestions for activities are given here]

Continue question and answers
[Could expand / expect the scope of the questions to be beyond the topics of Gaia and even astronomy]

Gaia pop quiz
[Create a simple, multiple-answer quiz to do with the students based on all the content covered through the mornings event. You could create answer sheets for the students to fill in or do ask them to raise their hands as you give them the 3 or 4 options for answers]

Parallax continued – hands-on demonstration – see Appendix 3 for example instructions
[Depending on the size of the group and provision of space, could split students into smaller groups and all could participate, or try this as a demo at front of the room using selected volunteers]

How do telescopes work? Make a basic telescope (if enough space, time and equipment students could make their own or in small groups `http://www.bbc.co.uk/programmes/p00n6zkf`)

Distances in space - powers of 10 – see Appendix 4 (or Dutch only version see ESERO NL exercise, http://www.ruimtevaartindeklas.nl/lespakketten/reis-door-de-ruimte-in-machten-van-10)

Make a model of Gaia (provide template)

Orbits (hula hoops and marbles – see)

Conclusion

[Summarise what you have done during the morning, why (revealing some facts/ what you have learnt) and how you have done it (showed how the Earth rotates while it orbits the Sun)]

I couldn't have done this with you (gesture to entire audience). You can find out more about the Gaia mission on the ESA website [English only] or [give website for local/national Gaia outreach information].

So, I would like to thank you, thank you and thank you.

My name is […], thank you, goodbye.

Appendix 1

Optional demo: Sun Blocks out Stars

What: Stars are visible at night, but not during the day.
Why: During the day, the sun lights up the atmosphere, which outshines the faint starlight.
How: We will demonstrate this by using two volunteers, one for the sun and one for the star.

Needed:
Two torches, curtains to darken the room and to stand behind, a light switch that lights up the room.

Introduction:
The Gaia telescope is going to observe a billion stars.
Question: When do we see stars? That's right, we see them by night.
Question: Why do we only see stars at night? At day, the sun is too bright to see any stars.

Asking for volunteers:
How does that work? To find out, we will need two volunteers:
One of you is the sun, and the other is the star. Who wants to be a star? Who is the star of this class?

Interactions:
Ask their names. You can ask them questions: "What do you want to be when you're older? Why are you a good star. Are you ready to be a star? Are you ready to shine?"

Control: Where and How?
Draw all curtains to darken the room. Now it is "night".
One volunteer will stand behind the curtain and switch on the torches ("stars"). When he presses the torches again the curtain ("atmosphere"), their light will be visible in the darkened room.
At your sign, the other volunteer will switch on the light in the room. Now it is "day". The torches ("stars") will not be visible, because the bigger lamp ("sun") lights up the curtain ("atmosphere").

Target reactions: Humour and Excitement
You can ask the children to shout "Day!" when the "sun volunteer" switches on the light, and "Night!" when he switches them of, together with day or night gestures (day can be: looking happy and raising your arms, night can be: closing your eyes and laying your head on your hands like you're sleeping).

Repeating what we've learned
So, "star volunteer" has shown us that we can see the stars at night when it is dark, but then "sun volunteer" has shown us that, when the sun lights up the atmosphere during the day, the stars are too dim to be seen. Thank you, perfect! You can sit down again. Give them a round of applause!

Appendix 2

Optional demo: Apparent size

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Lets now look at other stars

What? Change of apparent size of objects due to distance

Why? How does distance affect our observa9on; Gaia is going to be doing this

How? On stage + experiment to try at home

Technical Notes

Sun hats; space/distance on stage; images on slides in background

Volunteers

How many, how will you use them: 2 people with hats, one placed further away, audience will tell us how the size(s) appear(s) to change, although we know they are the same size

Interactions

imagine power lines, eclipse, leaning tower of Pisa; find two people

Target reactions

How will you create **Humour** and **Excitement**: *crowning parEcipants with sun hats; use teacher and small child; everyone say hello to X,Y or clap*

Control

Where and How: lighthouse; move teacher to back/ have kids move teacher to back

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We know the Sun is bright, so why is it dark at night?

Alternative versions:

Equipment: could simply ask for two volunteers or have two objects of the same size for volunteers to hold

[Ask for students names as they arrive at the front with you]

These [objects and [name of volunteer students]] are going to represent stars that are roughly the same size. [Ask one volunteer to stand in front of group and one to stand as far away as possible; adapt depending on space available].

Everyone hold out your arm and make pinchers with your thumb and your first finger. We're going to measure the size of the two stars. Which star looks bigger to you? Which one looks smaller? Lets ask [the star that is furthest away] to walk slowly towards us, watch how they appear to get taller and taller.

Let’s thank our volunteers [name of students] and give them a big round of applause as they sit back down.

If space limited:
Equipment: none
Everyone hold out your arms in front of you with your fists together and thumbs up. Close one eye and watch carefully as you slowly move one of your thumbs towards your nose. What do you notice about the thumb that is by your nose? Etc, etc.