Stretched mattresses and tiny solar systems

communicating STEM without metaphors

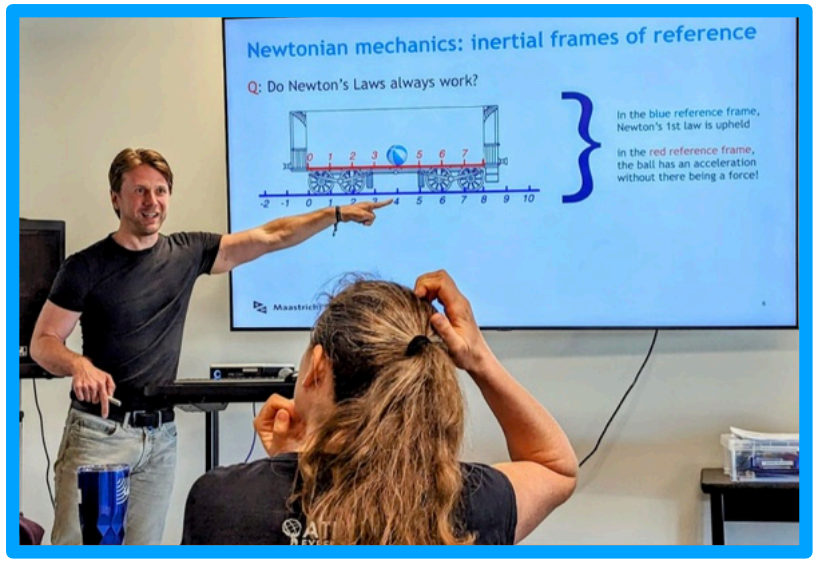
Gideon Koekoek

STEM Communication and Outreach Event
11th november 2024

Who am I? :)

gideon.koekoek@maastrichtuniversity.nl

www.maastrichtuniversity.nl/gideon.koekoek



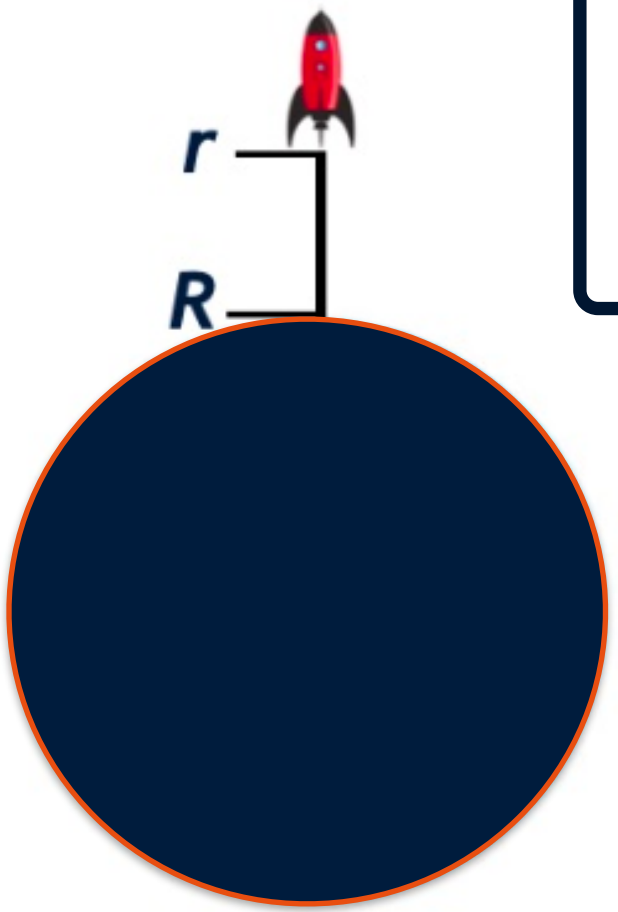
- MSc theoretical physics, VU Amsterdam
  PhD theoretical physics, Nikhef,
- MSc Education, VU Amsterdam,
- Associate professor @ Maastricht University,

- Coordinator Virgo Educational Outreach,
  Co-coordinator Einstein Telescope Consortium,
- Board member & Outreach coordinator at the Dutch Black Hole Consortium,
- Scientific lead of the Einstein Telescope Education Centre,
- Lead of the MaGIC program
  (start in Summer 2025).

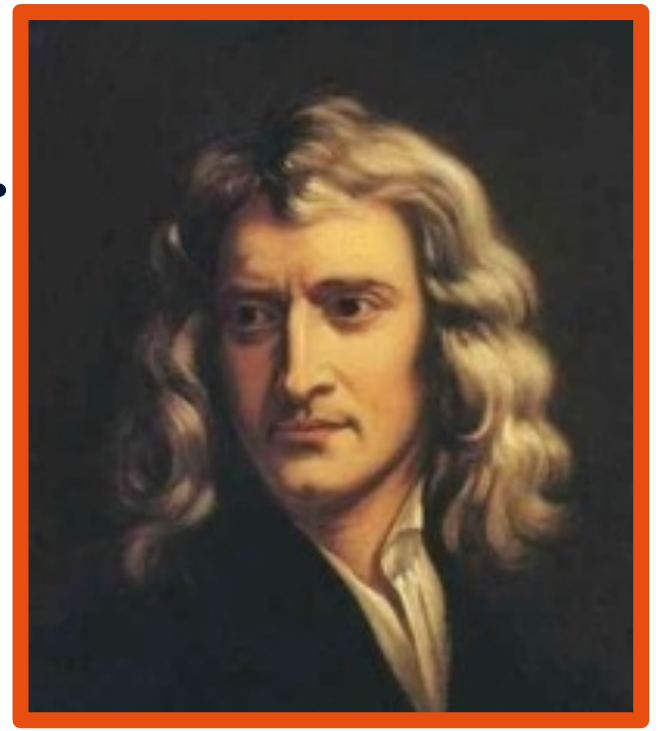
Maastricht University

Why are black holes black?

Why are black holes black?



$$v_{\text{escape}} = \sqrt{\frac{2\,G\,M}{R}}$$



$$R = \frac{2\,G\,M}{c^2}$$

Questions:

How do Newton's Laws apply to things that have no mass?
How can light slow down it is should always go with *c*?

‘Newtonification’ of science

In (science) understanding, we tend to bring everything back to things we have seen and understood earlier.

Advantages:

Easy to understand and visualise

Quick and effective way of getting the basic idea

Overcomes trepidation

Disadvantages:

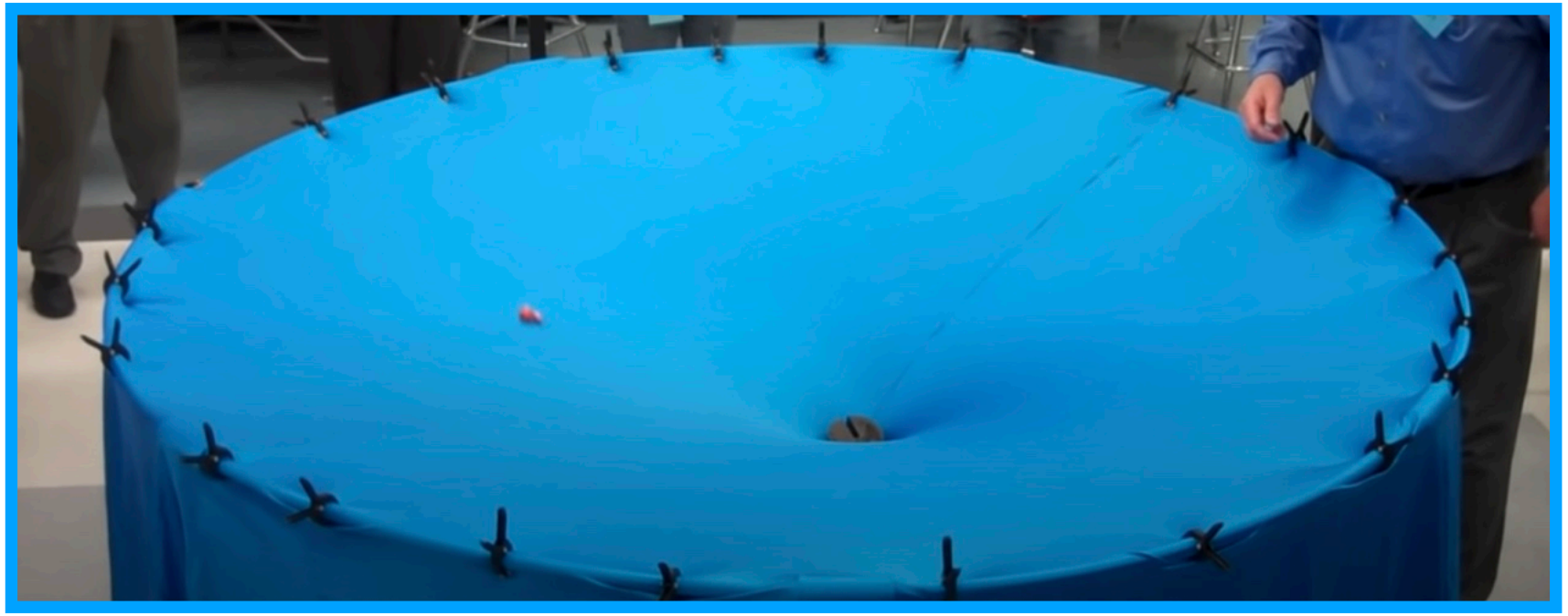
Audience does not know where the metaphor breaks down

Imperfect foundation for further understanding

Misses true essence!

A few more examples

"Gravity is a stretched surface, like a heavy object on a trampoline"

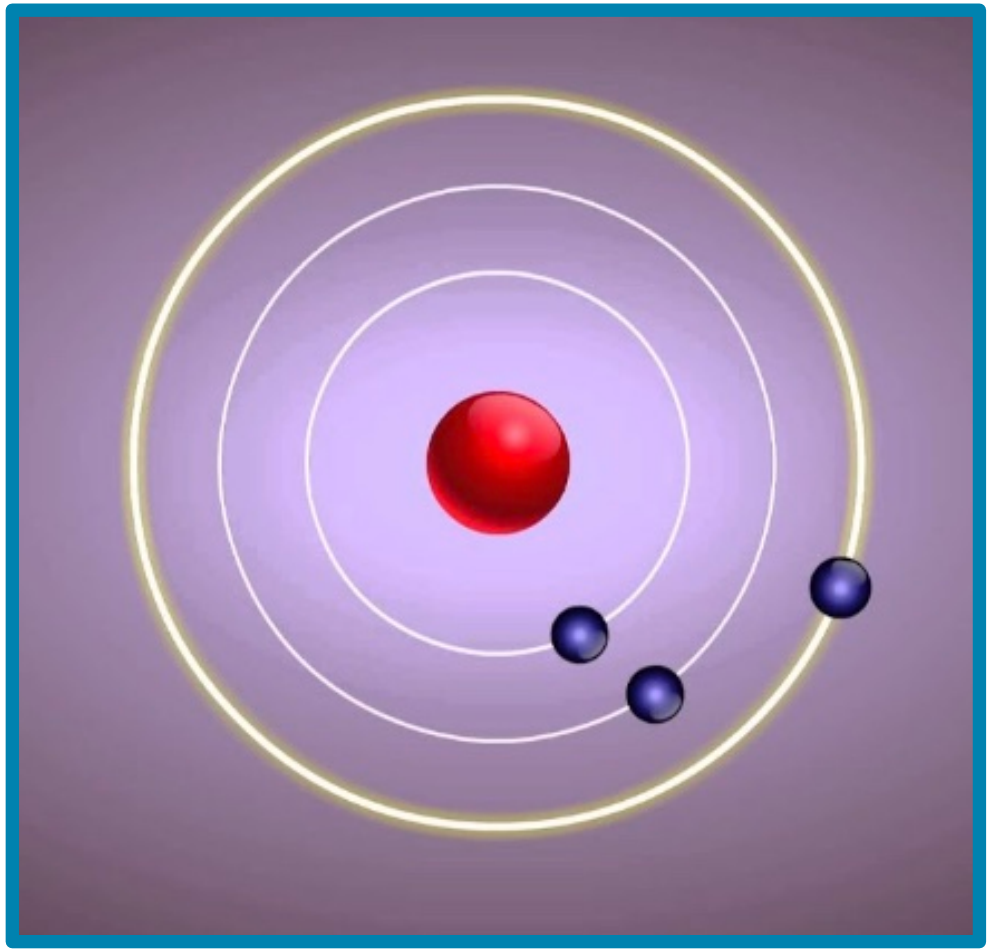


Question:

Where does the gravity come from that makes the ball push into the trampoline?

A few more examples

"An atom is like a tiny solar system."



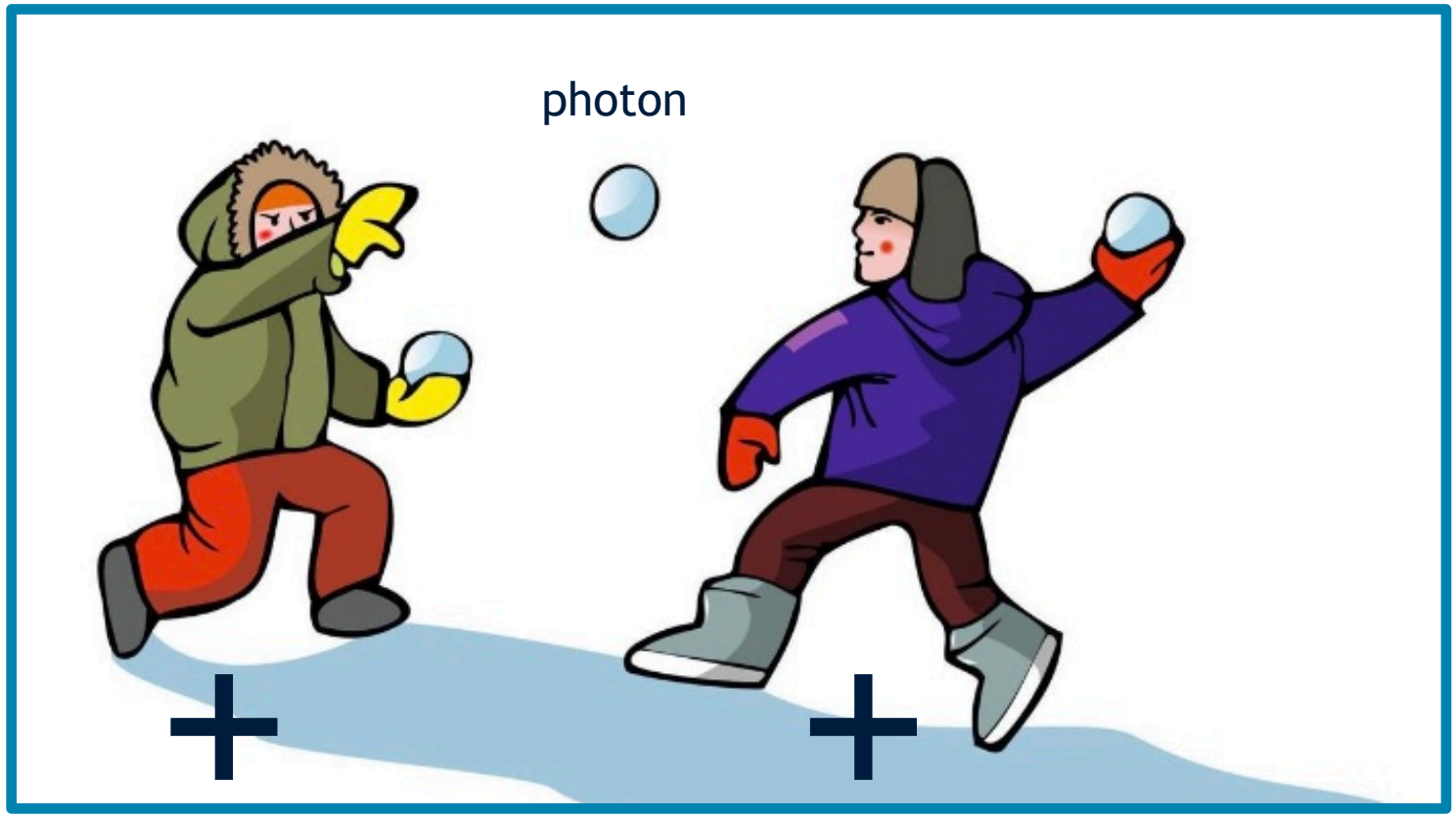
Questions:

Why do only specific colours come out?

Why don't these 'planets' crash?

A few more examples

"Electrostatics is due to photons bouncing charges away from each other"



Questions:

How do *unequal* charges attract?

Where do the photons go afterwards?

Why do we use metaphors?

Advantages:

Easy to understand

Quick and effective way of getting the basic idea

Overcomes trepidation

Disadvantages:

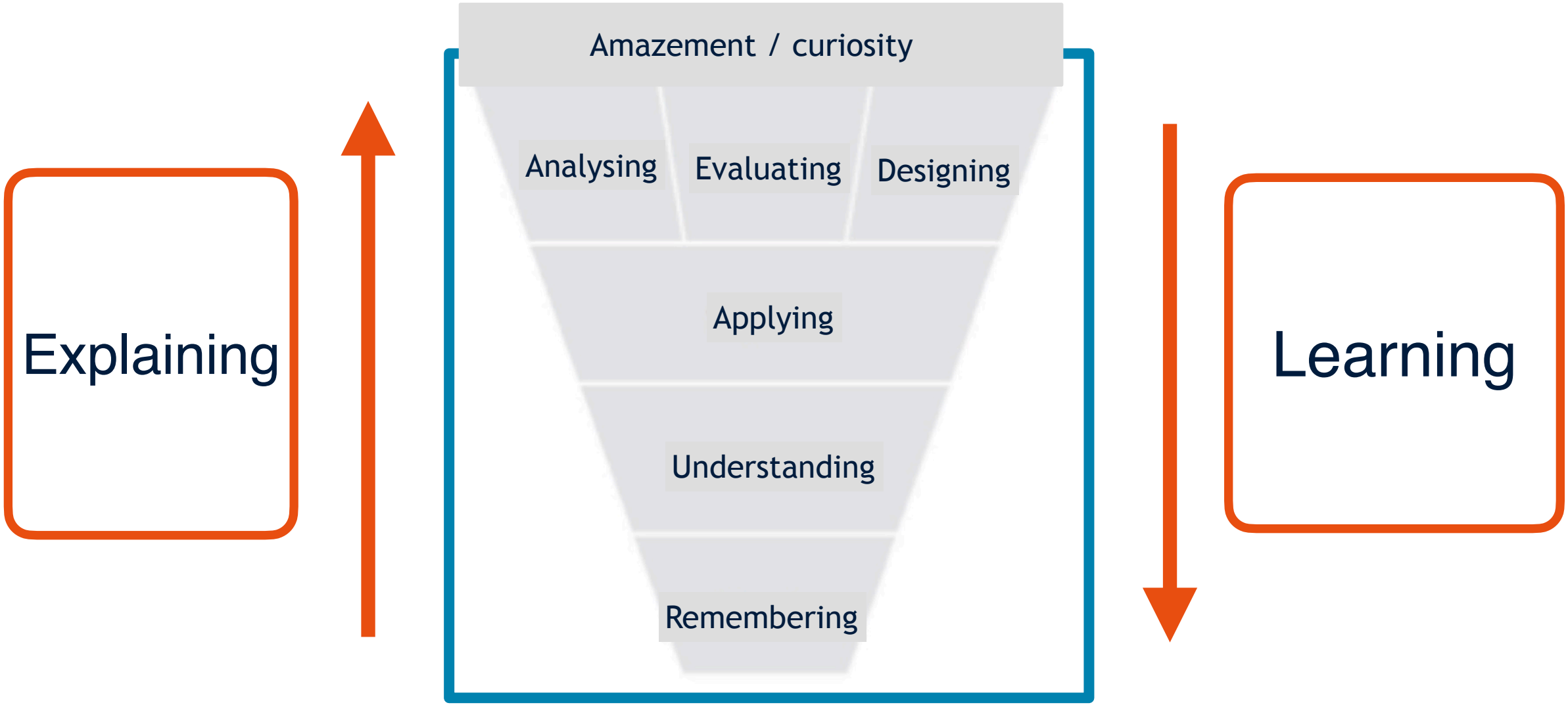
Audience does not know where the metaphor breaks down

Imperfect foundation for further understanding

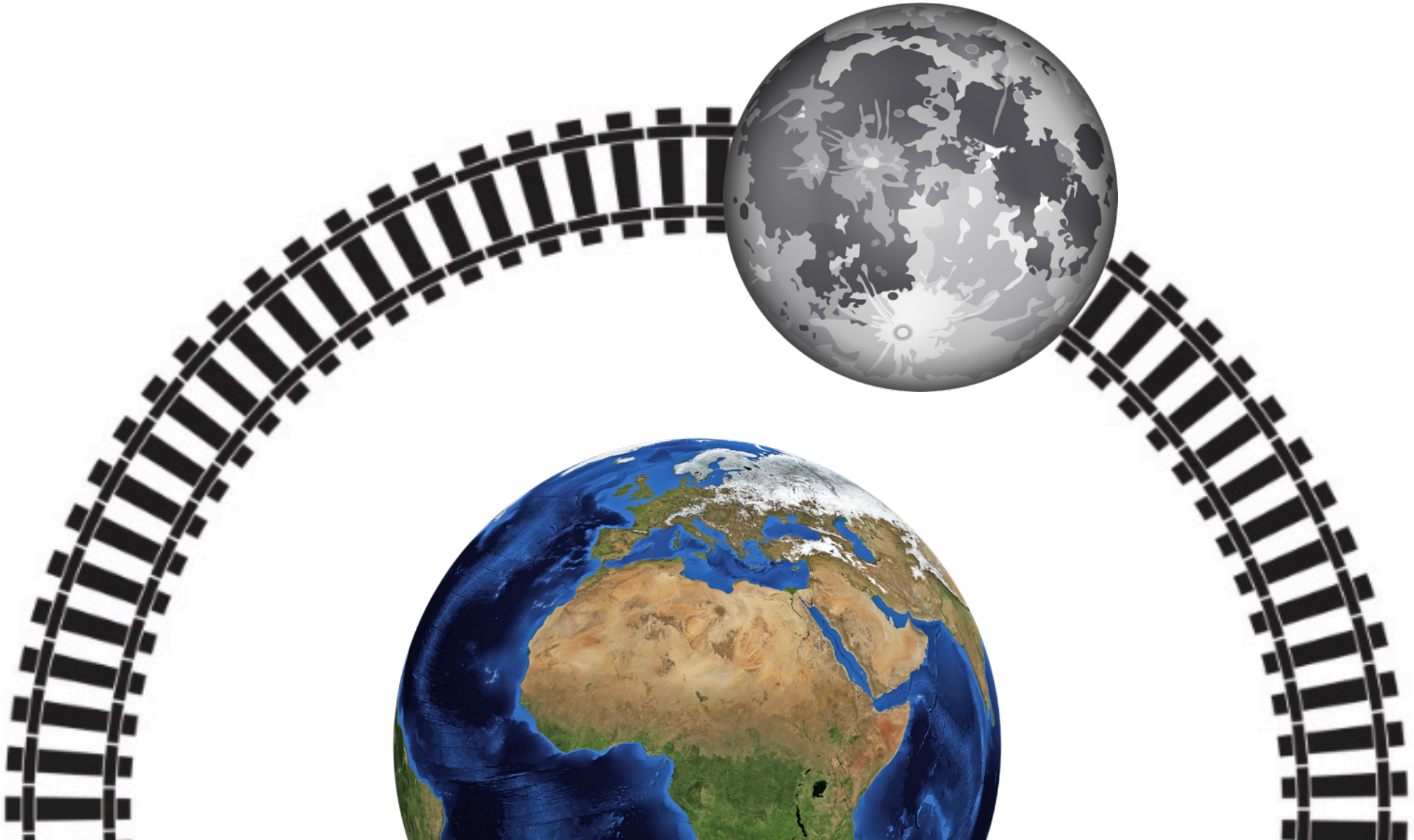
Misses true essence!

If communication is about visualisation: all good!
If communication is about understanding: use a different method.

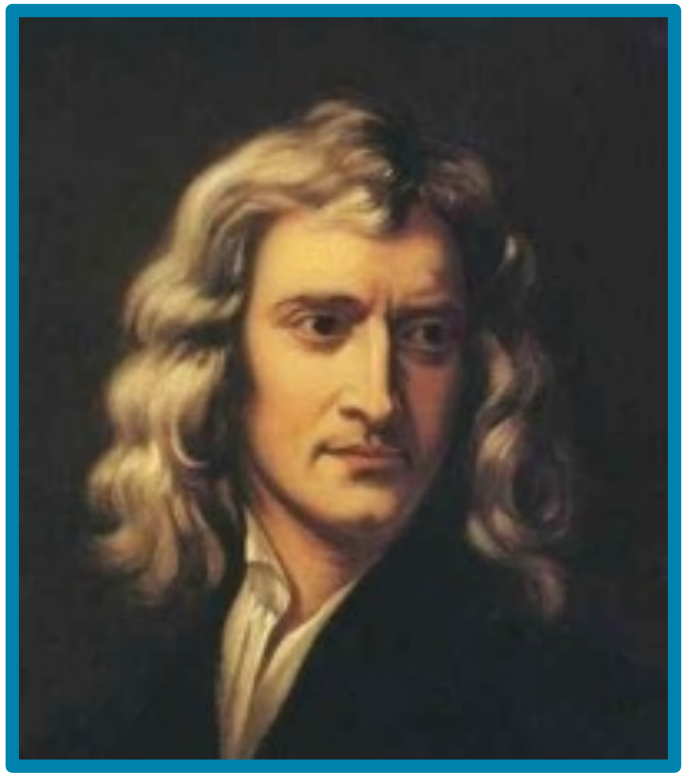
Thinking like a scientist (let them own the material!)



Steps 1&2: amazement and analysing



Step 3: applying



Mass measures how much an object speeds up due to gravity

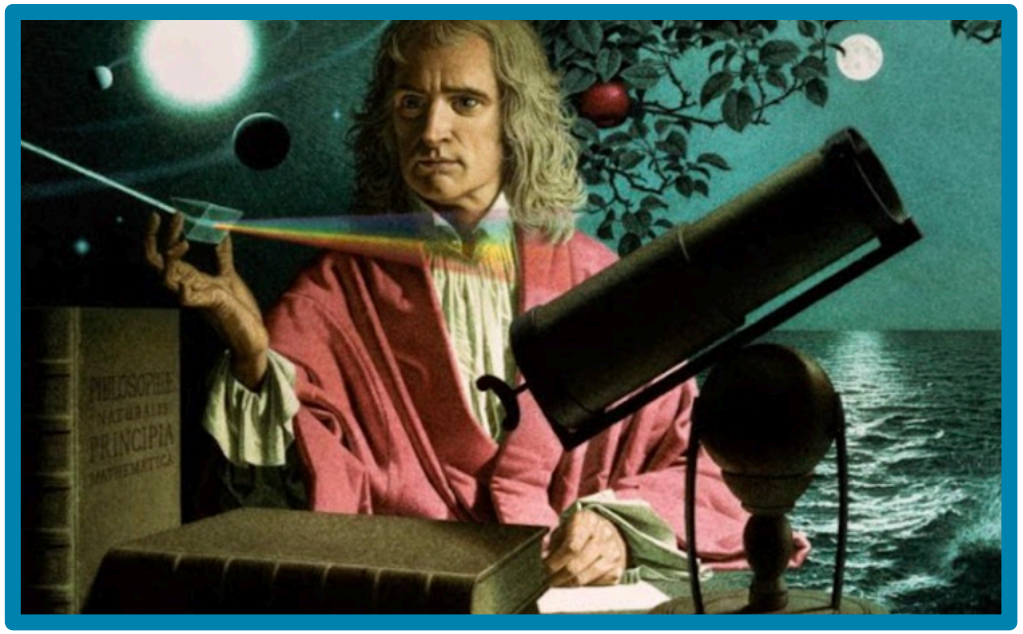
Mass measures how much an object does not like to speed up

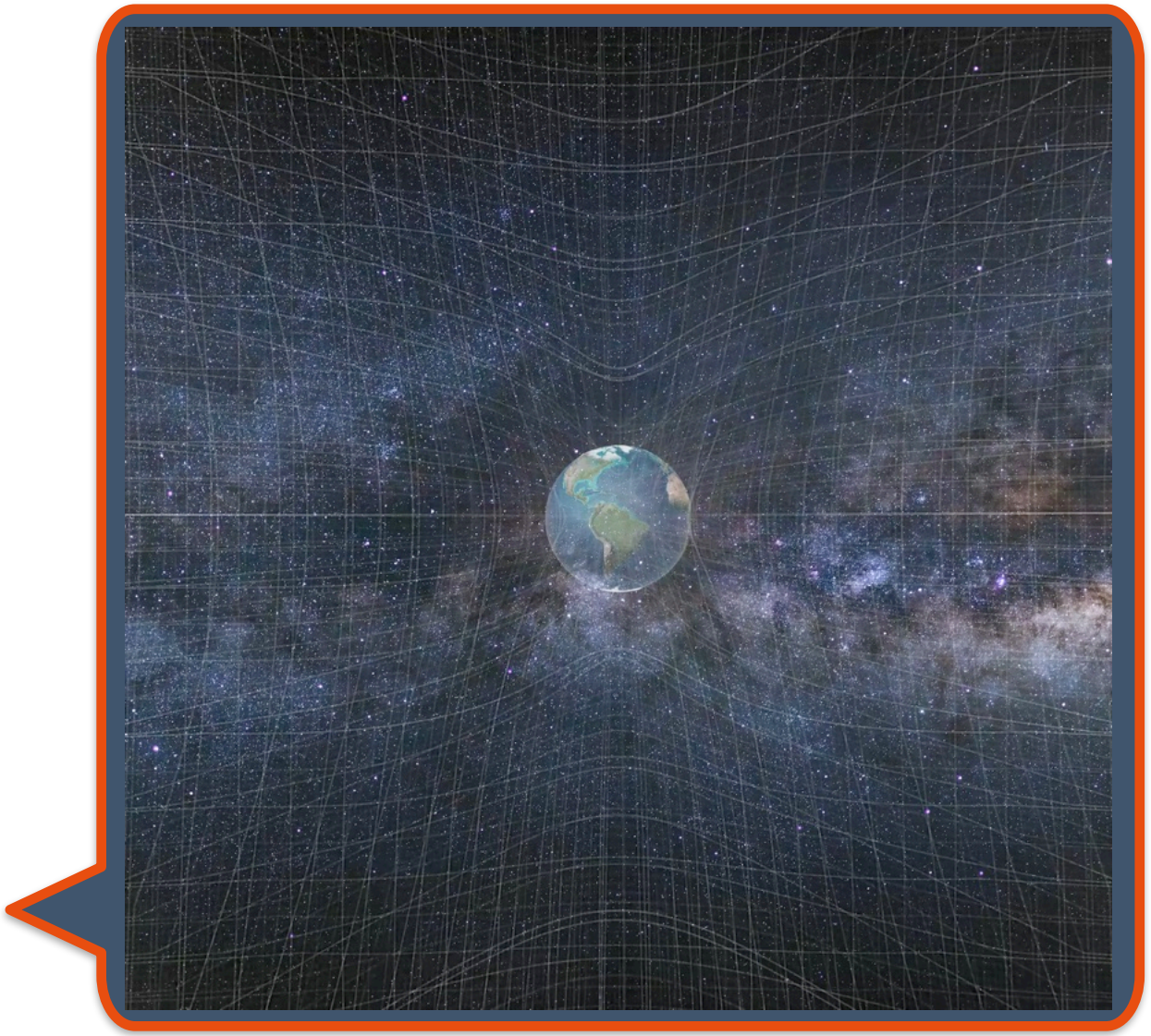
Train track is universal!

Step 4: understanding

Two meanings of mass

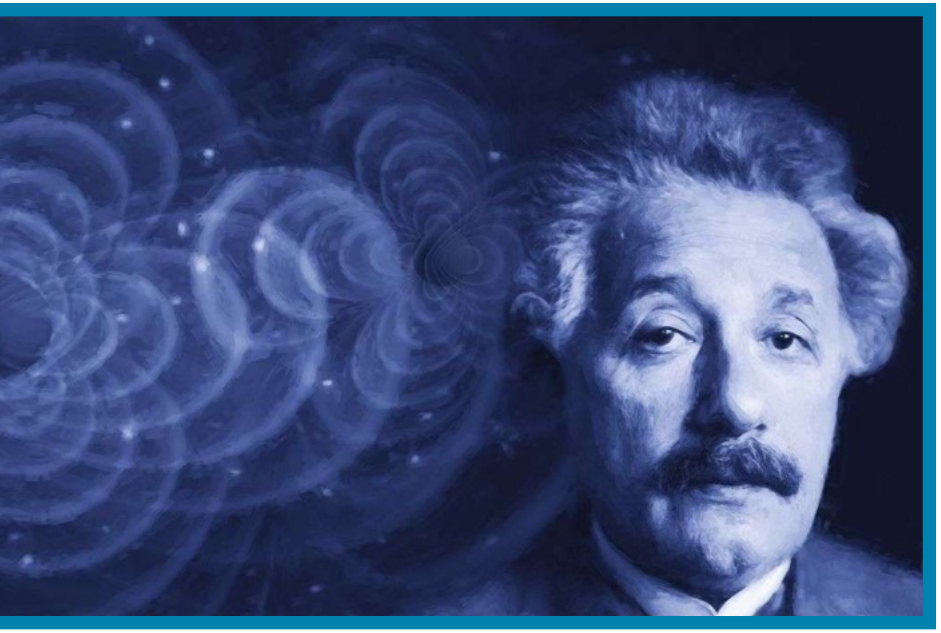
→ **Space is curved!**

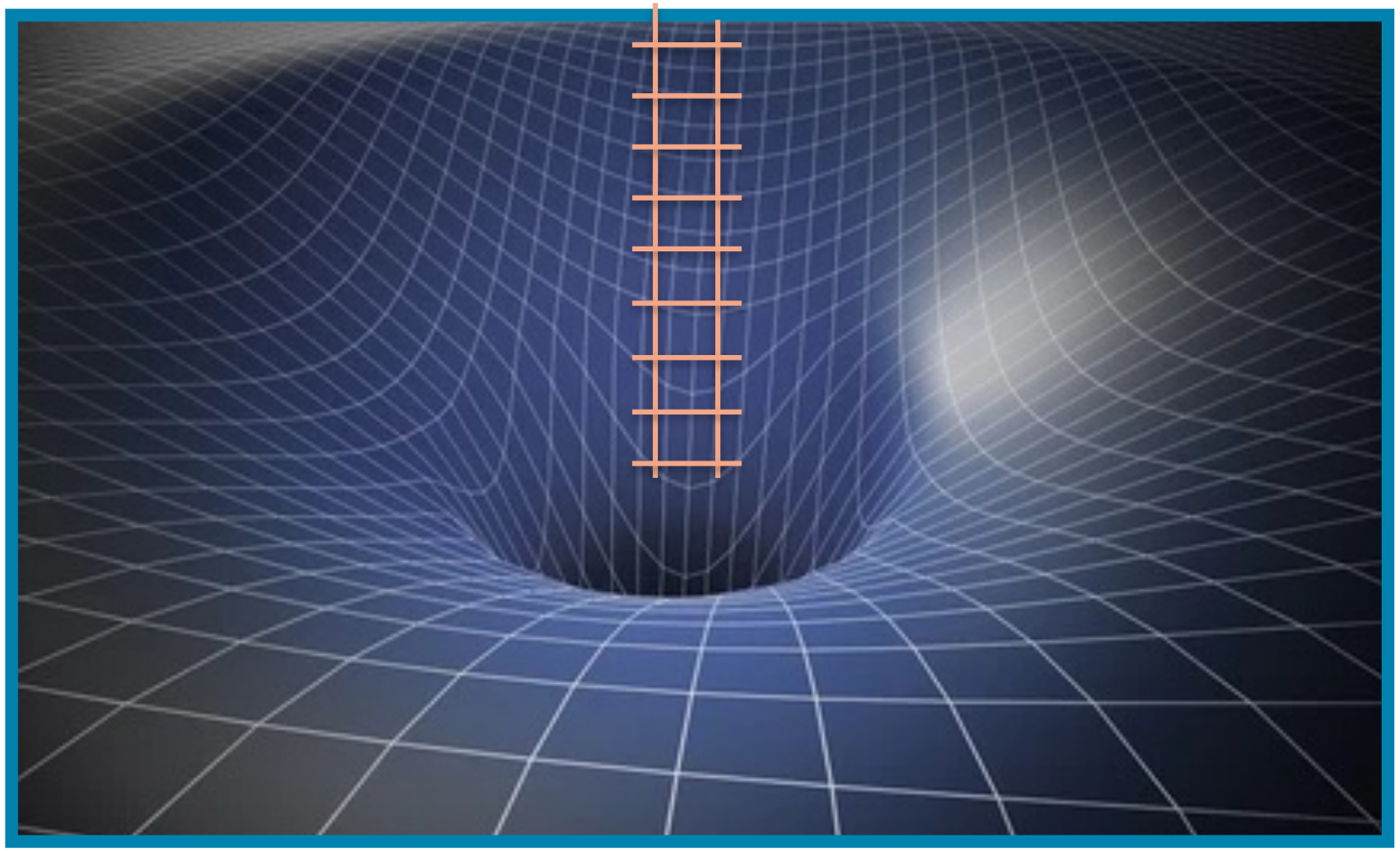




Why are black holes black?

Because the train tracks are all curved inward!





The Einstein Telescope Education Cente

Einstein Telescope

News

Discovery Museum Kerkrade gets education centre about the Einstein Telescope

The 'Einstein Telescope Education Centre', or ETEC for short: this is the name of the education centre that the Dutch Discovery Museum Kerkrade will set up in its five-storey Cube building. Schoolchildren can work there on teaching materials based on current research on the Einstein Telescope. In addition, ETEC will provide a stage for at least three years from school year 2024-2025 to get acquainted with engineering and science education.

www.einsteintelescope-emr.eu/blog/2024/06/26/einstein-telescope-education-centre-officieel-geopend/

Part 1:
Watch 3D-movie

Part 2:
Follow interactive lecture

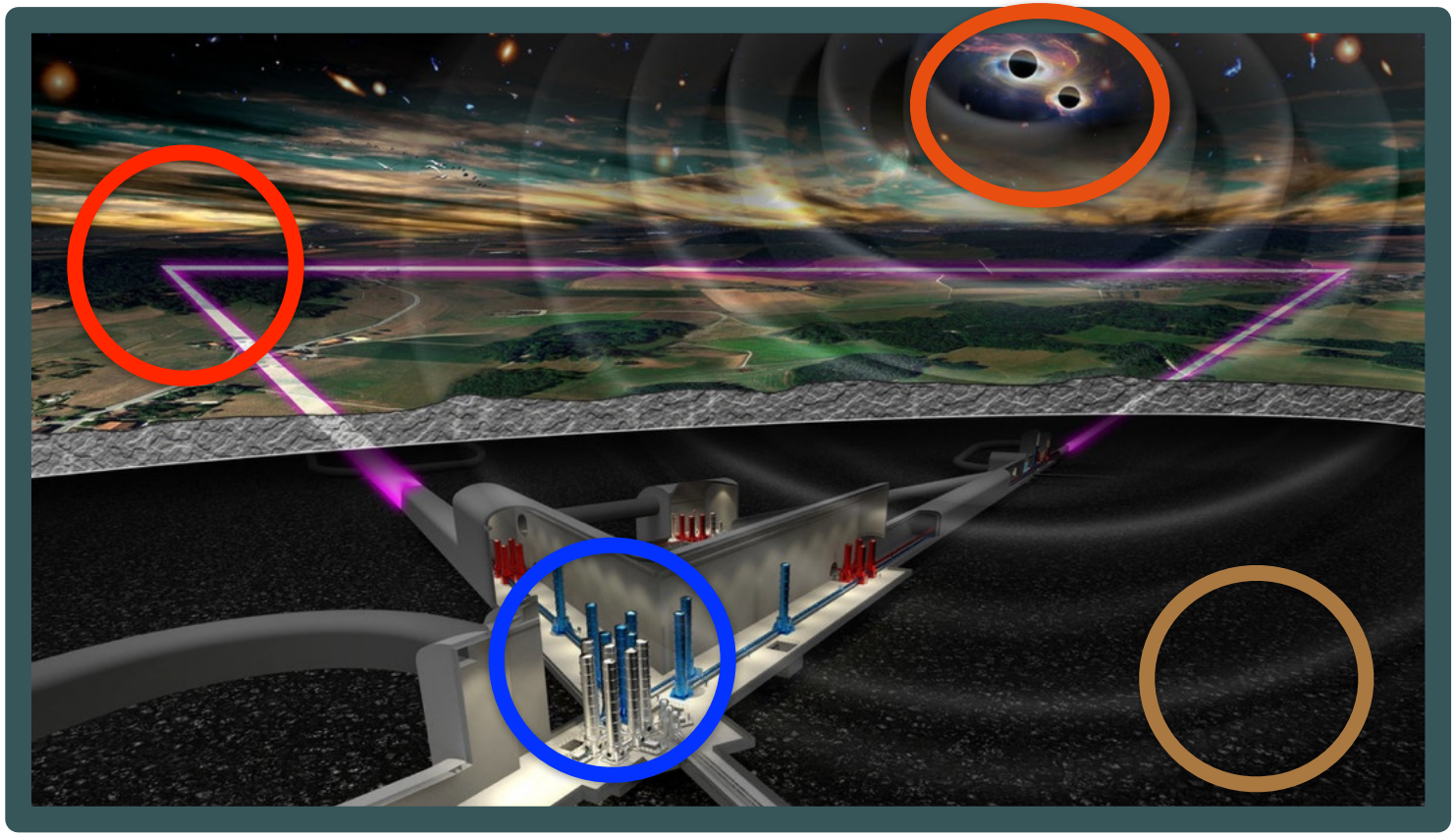
Part 4: Report on findings

Part 3: do workshops

Maastricht University

Educational workshops

- **Lasers**
  Measuring using laser light
- **Vibrational**
  Minimising mechanical vibrations
- **Data analysis**
  Locate black hole collisions in data
- **Geophysics**
  Acoustic investigation of soil



Einstein Telescope science is very compatible with every day experience.

Maastricht University

DA online workshop

- 90 minute online workshop, for use in classrooms.
- Students get detector data.
- Have to find the gravitational wave in it, and locate the black holes in the sky.
- Follows Bloom's 'inverted taxonomy'.

Universiteitsfonds Limburg | SWOL |

FONDS Ernest SOLVAY

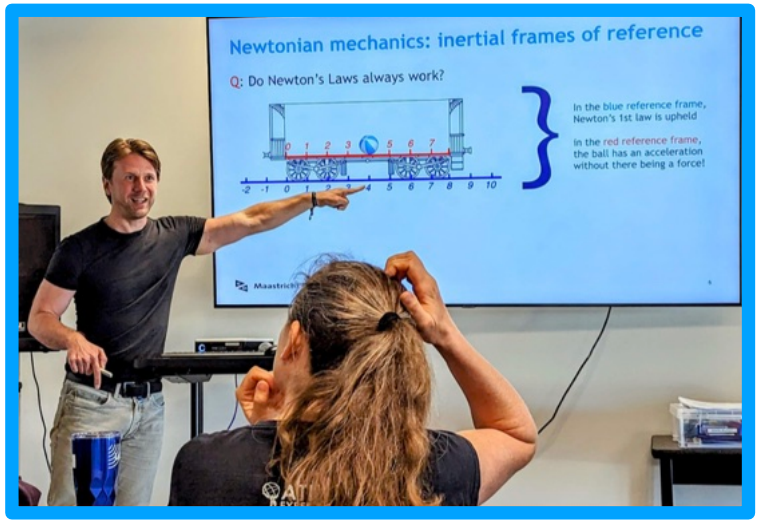
SOLVAY Progress beyond

Maastricht University

MaGIC: European teacher training

- ~ 30 high school teachers from the countries around EMR-region.
- 7 days, 6 nights, local hosting in EMR
- Training in physics, technology, and didactics
- Back home: start local teacher communities

www.ligo.caltech.edu/WA/page/lho-ipa-pd



Maastricht University

Conclusions

- We tend to learn novel things by adjusting what we already understood before; explanations often come in metaphors,

- Metaphors are great for visualisation, but not (always) for explanation,

- One way to communicate STEM: amaze audience, and let them feel like scientists (let hem ***own*** their understanding!)

- Put into practice: **Einstein Telescope Education Centre:**
  Opened June 2024, taking ~30 school class visits per year

- Put into practice: **Online black hole workshop:**
  In development; output used for educational research.

- In development: **International teacher professionalisation MaGIC:**

Thank you!

Einstein Telescope Education Centre:
www.discoverymuseum.nl/activiteiten/etec/

Lesson plans on general relativity and gravitational waves, for secondary education

SCAN ME