The children of the Moon
Hijos de la Luna

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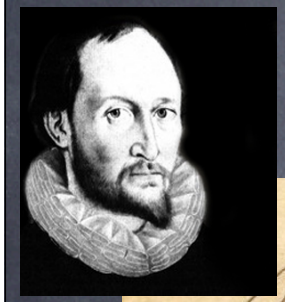
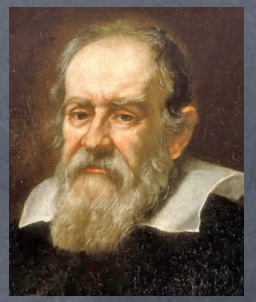
December 2, 2009

1609: first look at the Moon through a scope

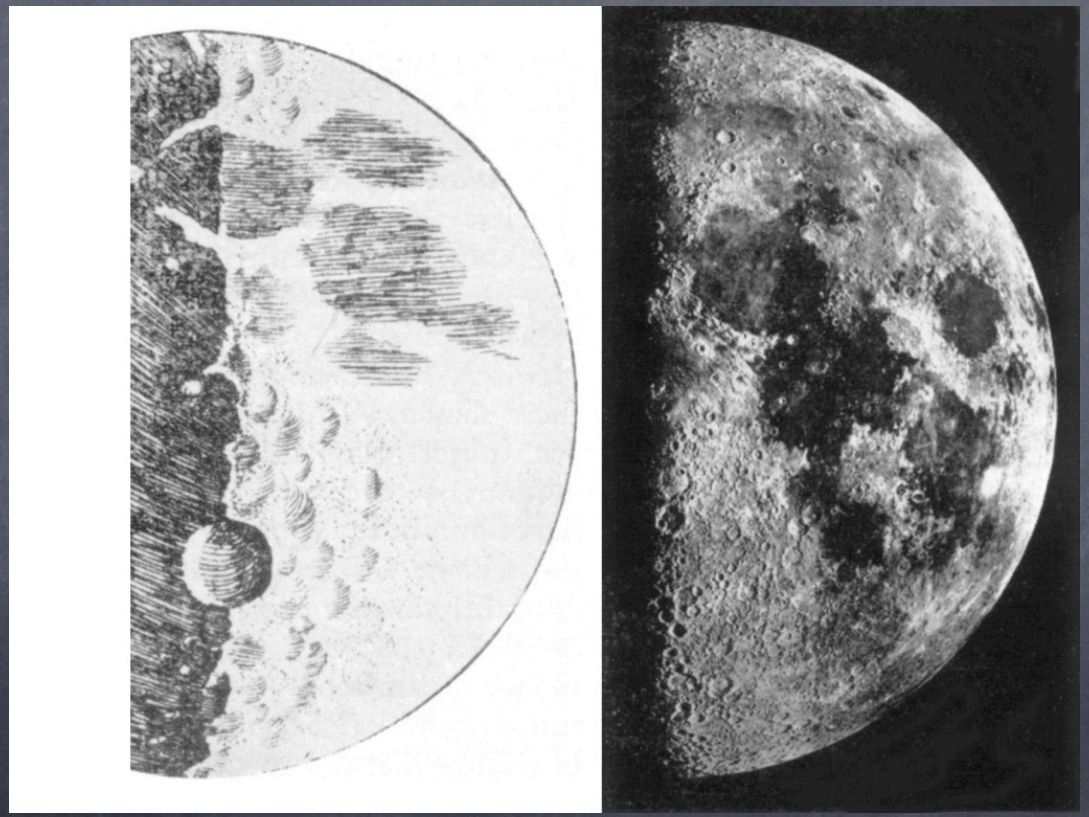
- Thomas Harriot



- Galileo Galilei



Ending of Aristotelian thinking



New mountains higher than Earth's mountains

XO for Astronomy

- Adding a scope in front of the camera

- Using half-binoculars

Technical data

- The camera
  - 640x480 pixels
  - 30 images/s
  - automatic gain
  - Moon Diameter = 6 pixels
- With current scope added
  - 10x magnification
  - Moon Diam = 60 pixels

Specifications

- Spatial Resolution:
  9 pix for largest visible craters
  => x17 magnification
- achromatic, compact and afocal scope's lens
- off-the-shelf technology:
  x10, x16 magnification (binoculars)
- customised solution: x20 zooming factor?
- Cost: prototype = 30-60 €/unit,
  Final cost must be few $/unit for large ordered quantities (~10 000 ?)

Preliminary tests

- Robust and stable assembling but...
- Saturation issue
- JPEG Compression
- Moon Diam ~65 pix

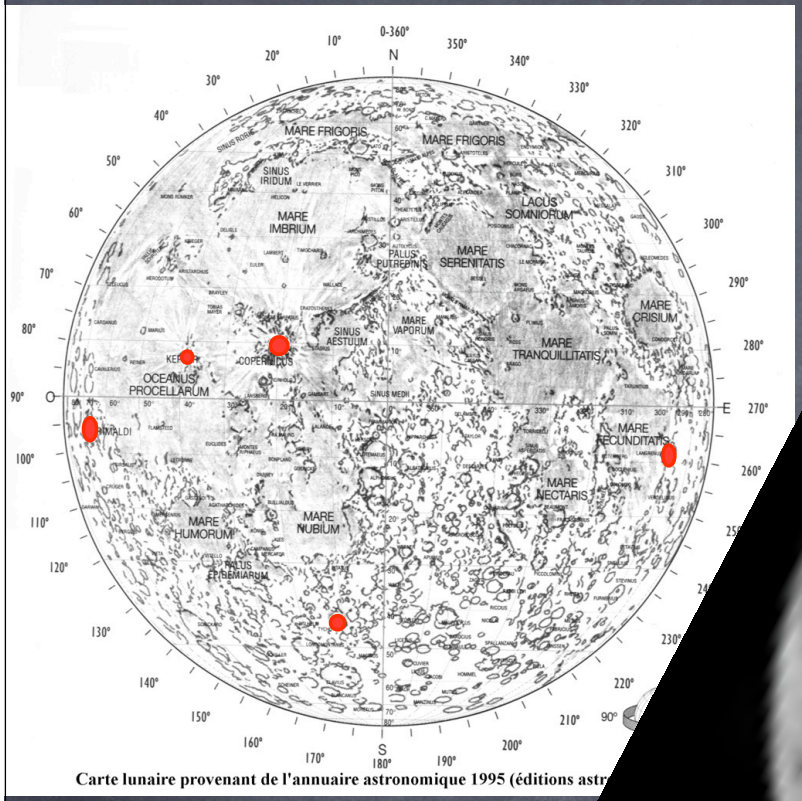
Preliminary tests

Solutions ?

- Use neutral density filter(s)
- Manually adjust the camera gain
- Load raw images
- Increase the magnification

Simulated images

(here, I have degraded the natural resolution of a very nice image of the Moon down to more reasonable values, which correspond to the various technical solutions that we could dispose of...)



Carte lunaire provenant de l'annuaire astronomique 1995 (éditions astr

16x


Simulations still, 16x magnification

Pedagogical project

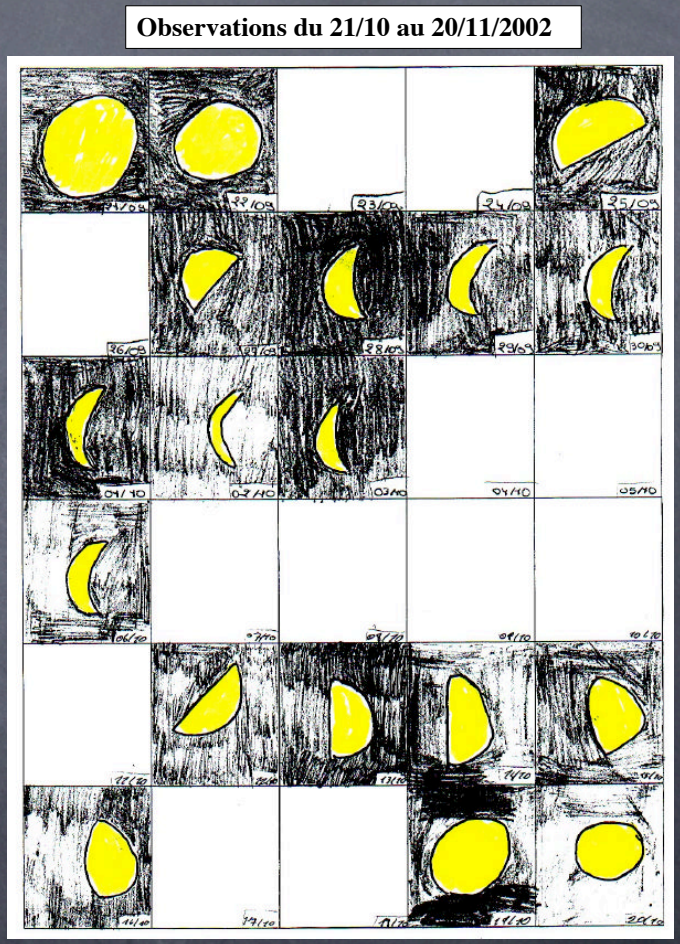
- 1-My very first image of the Moon
- 2-What is an image ?
- 3-Moon phases
- 4-Moon phases simulation
- 5-Shadows and Relief
- 6-The Earth-shine
- 7-Moon size and orbit
- 8-Earth-Moon distance

1- My very first image of the Moon

- **Strategy**: «Can we see the Moon ? When? Where?»
- **Forecast**: draw the Moon as you imagine it should look like today/tonight
- **Training**: testing the XO with the scope, simulation of spotting activity using a ball as a fake Moon (pointing, focussing, recording,...)
- Each pupil makes his/her own image **alone**
- **All pupils together**: debating about the protocol, observations, issues, discussion. Make a written report

1- My first image of the Moon

- **Discussion:** «Do all images look the same ?»
- **Comparison** and **selection of the best image:**
  - Image files transfer with other pupils, using the XO file exchange facility
  - Selection criteria: based on focus, orientation, brightness, composition, blur,...
- **Analysis**:
  - Size of the images?
  - Recording parameters? (date, time, location, weather,...)
  - Register all information in an **electronic 'science experiment notebook'**
  - What can be seen on the images? (bright and dark zones with various shapes)
- **Extension**: How big can you enlarge your image?

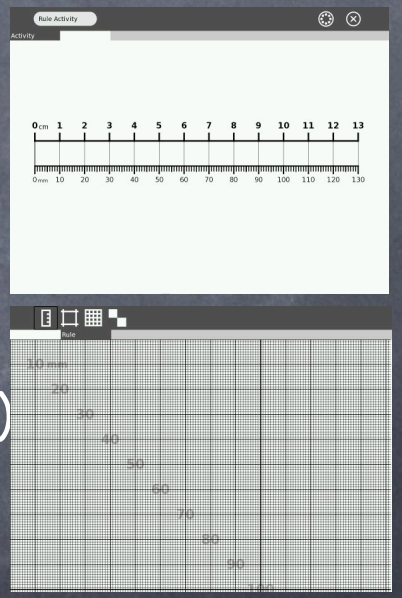


2- What is an image?

- Discovering the pixels
- Measuring the Moon size in pixels
- Drawing known objects with pixels (grid/mesh)
- Comparing with a picture of those objects
- How are the contours changed?
- Image quality/resolution

2-What is an image?

- New TOOLs to work out images (e.g.,Sugar > Paint, Ruler):
  - Circular templates of variable size
  - Measuring tools (ruler)
  - Changing the image size/orientation (rotation)
- How can you compare 2 images ?
- Saturation levels (brightness encoding)

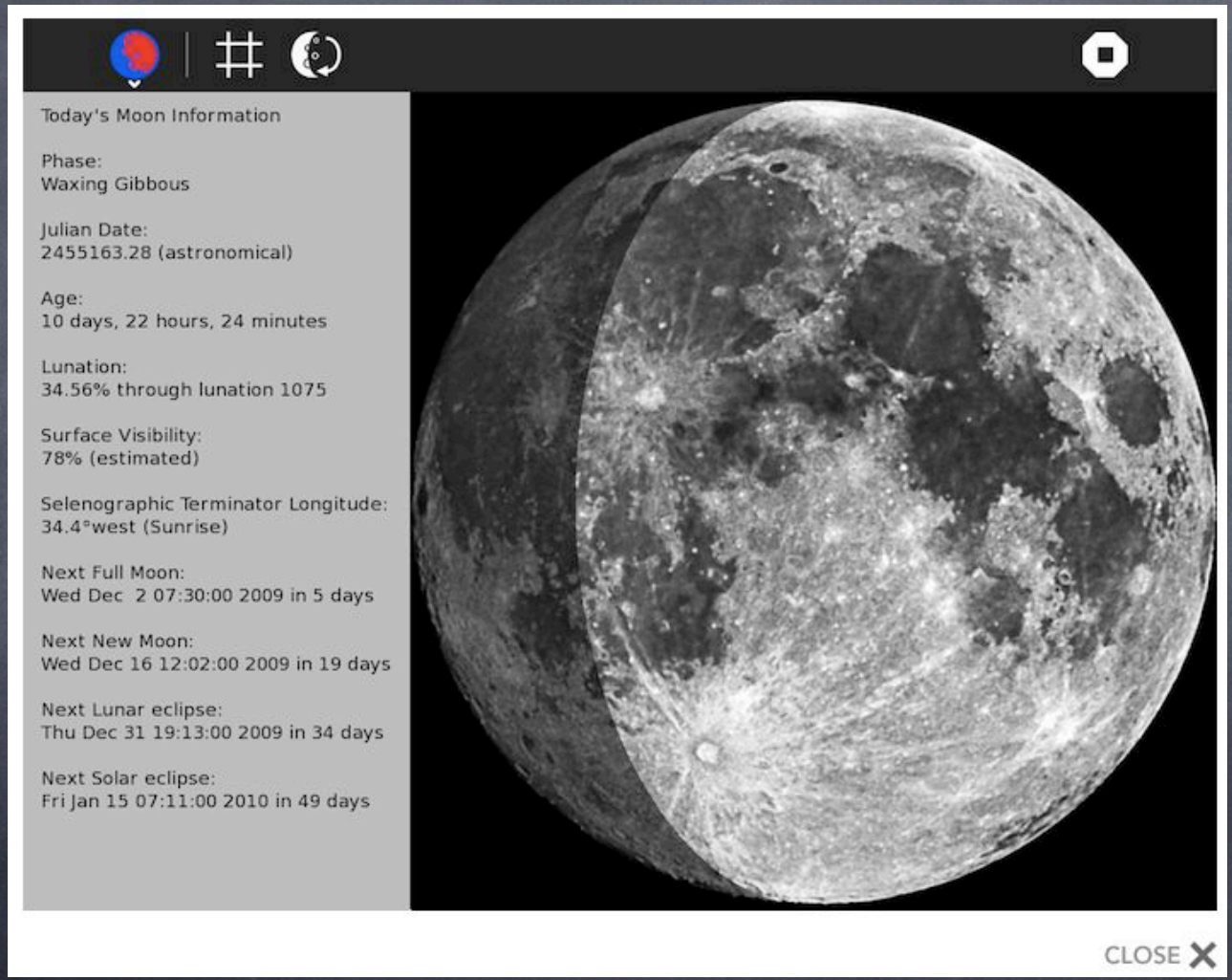


3- Moon phases: observing

- Debate: ask about the nature, duration and origine of the Moon phases, what they know the respective motions of the triplet Sun-Earth-Moon.
- Collect new images recorded along several weeks
- Comparative work: image analysis, the terminator line and its slow drift
- Experiment notebook: correlate the observability of the Moon (time, direction) with its illuminating phase

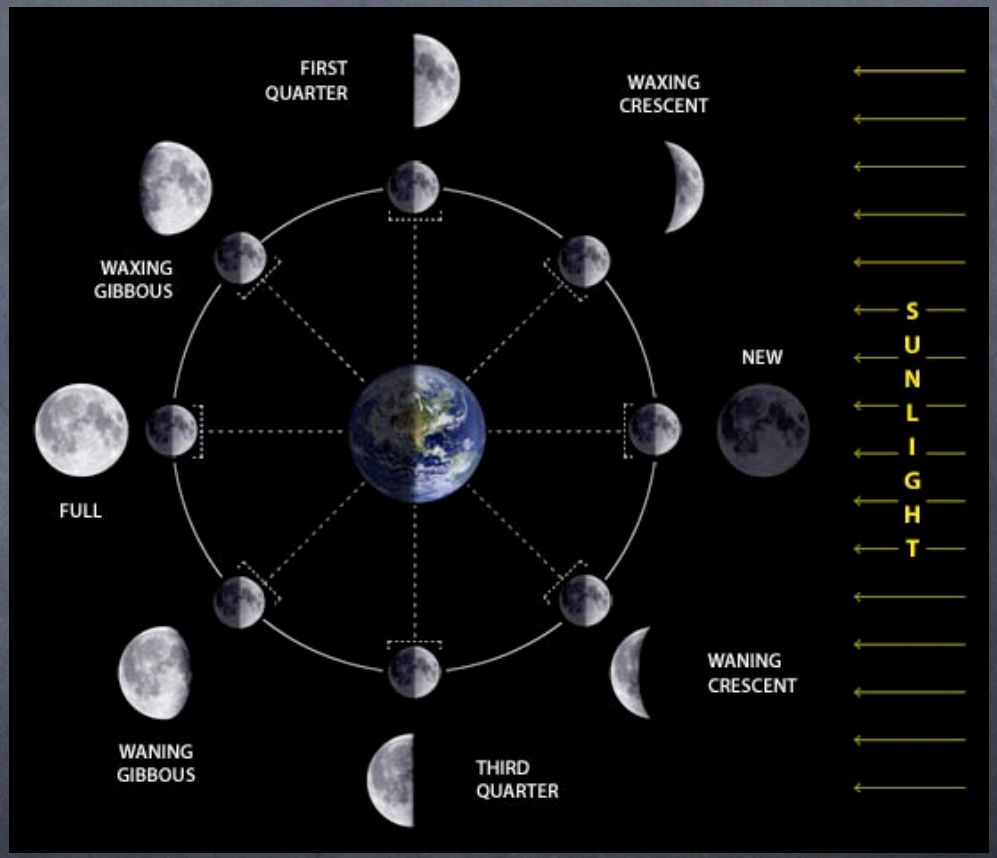
Link Sugar / Activity > Moon

existing tool: Sugar / Moon



Moon phases simulation

- Difficulty :
  escaping the terrestrial referential
- Pre-Requisite knowledge:
  - Sun-Earth-Moon motions
  - the Sun is the only source of light
- Collect and test various hypotheses proposed by the pupils about the nature/origin of the phases.
  (e.g., link with the Earth shadow?)
- Simulation: with a flashlight and balls
- The pupils mimic the successive positions of the Sun, Earth and Moon



4- Relief and Shadows

- Details of the Moon surface are revealed by the brightness variations: learn and name the major craters,
- Measure their apparent size and classify them
- The terminator line: why are the mountains and craters best visible close to this line ?
- Select phases when the relief is best evidenced
- Simulate mounts and craters on a ball, using mold and a flashlight. Make a picture of the simulation and compare with Moon picture (length and direction of shadows, illumination of the craters limb,...)

4- Relief and Shadows

- The reflecting power
  - Why are some regions more or less bright?
  - The Moon surface reflects the sun light, more or less efficiently
  - Experiment: illuminate a surface made with various materials and try to evaluate (better : measure) the quantity of light reflected by that surface (white or black paper, wood, soil, sand, water, aluminium foil...) make pictures of these experiments and of the surfaces.
  - Classify the tested material depending on their ability to reflect the light.
  - Test the impact of various inclinations of the light rays on the surface
- Conclusion: the brightness variations at the Moon surface can reveal variations of the soil itself

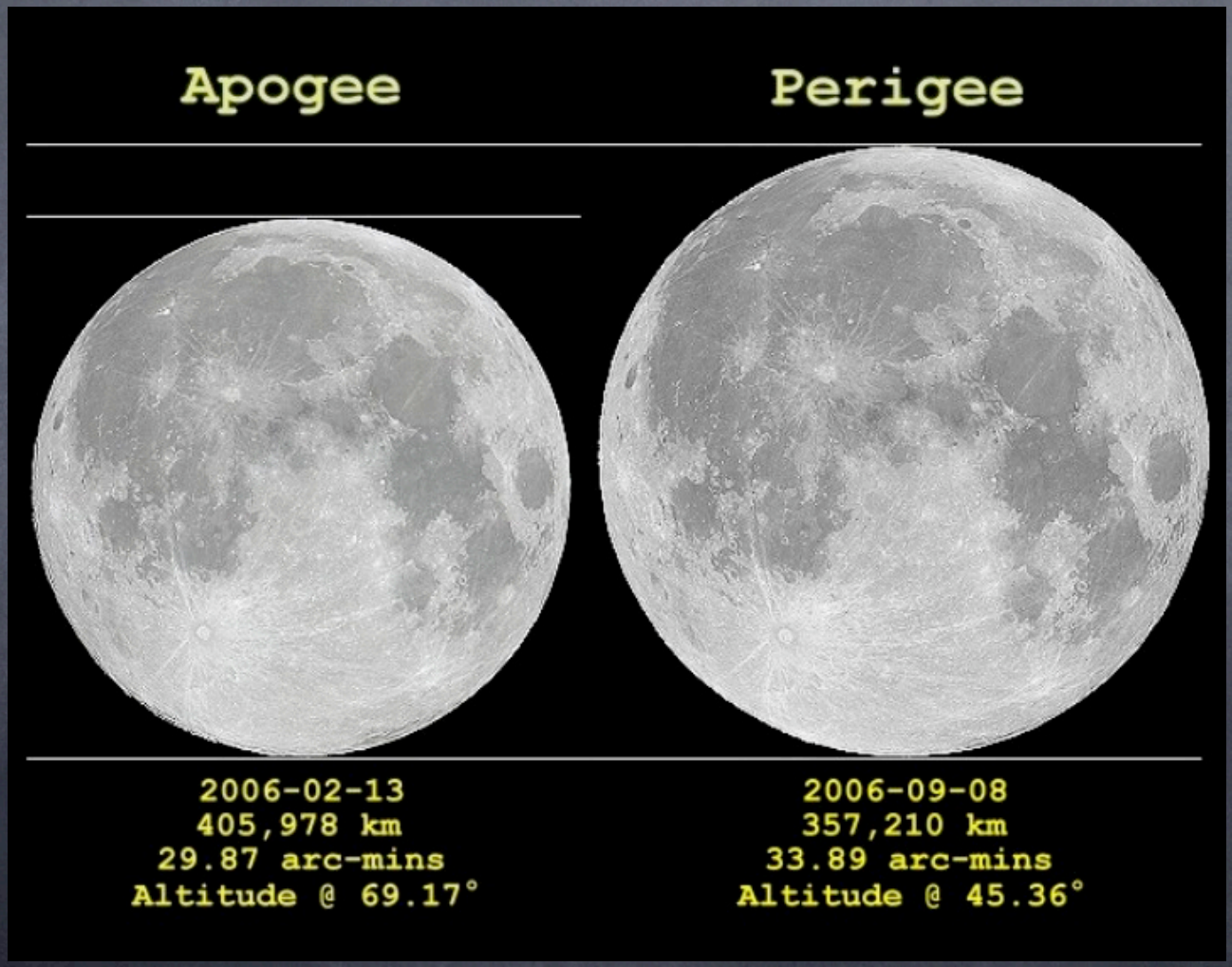
5- The Earth-shine

- Observation with naked eye, then try to make a good picture. (need to saturate the most illuminated part)
- Debate: when, where is it observed (what phase) ?
- Simulation : reproduce the related Moon phase(s)
- Simulation : Does the Earth also has phases ? what link with the Moon phases ?

  New referential for the pupil: (s)he is observing the Earth from the Moon. draw the phases of the Earth from the Moon and associate the Moon phases. Simulate (or play) and make picture with the XO-camera (without scope!).
- Simulation: use a reflecting (metal) ball (or a mirror) to mimic the Earth and a dark room la Terre. try to reproduce the Earthshine and make a picture (difficult !)
- Conclude: correlate the 'Full Earth' phase with the Earthshine observation.

6- Apparent size and orbit of the Moon

15%



6- Apparent size and orbit of the Moon

- Observation: the apparent diameter of the Moon changes along the time, why ?
- Apparent vs. actual size: play with various familiar objects, using the camera
  - Measure the variation in size of the image of a ball (or the head of a friend!) when it is more or less distant from the camera.
  - Use balls of different size and find the relevant distance where they appear to have the same size on the camera display/image.
- Debate: origin of the apparent size variation of the Moon: distance or volume?
- Simulate and try to conclude on the Earth-Moon distance variation:
  the Moon orbit is not a perfect circle... but an ellipse !
- Psychology of the vision: the Moon looks bigger when seen right above the horizon (compared to close to the zenith). Is it real or just an illusion ?
  Measure and conclude.

7 - Final questionnaire

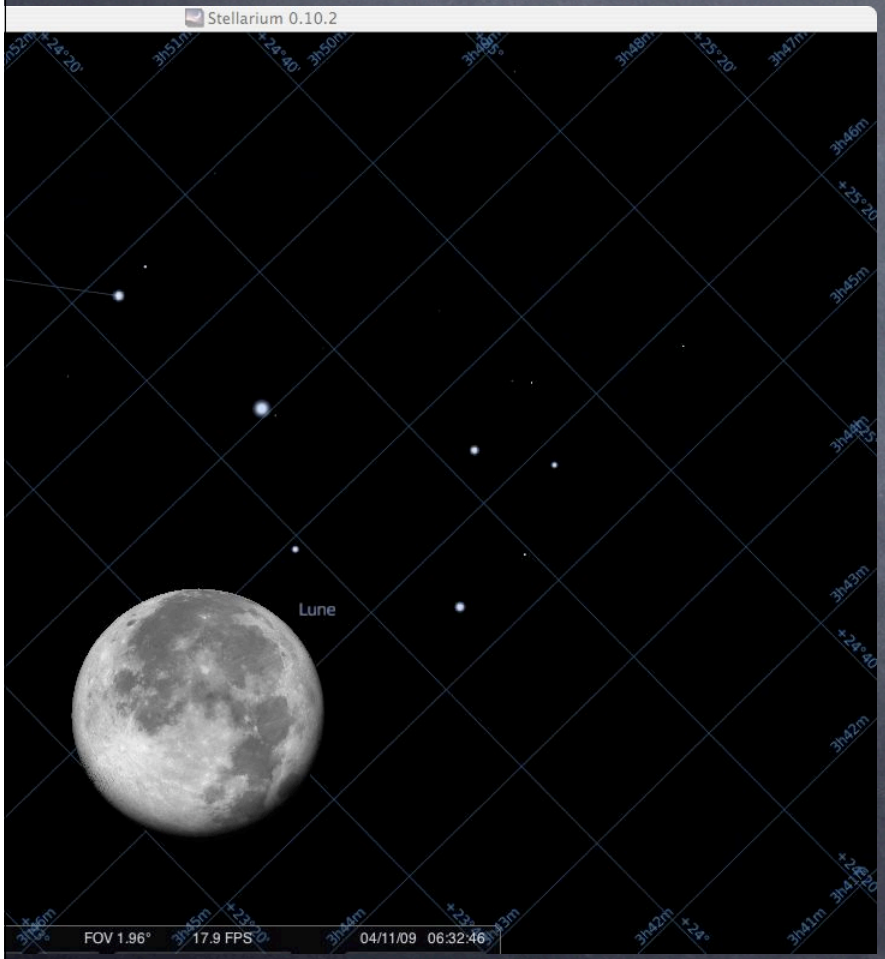
- Summary of what has been learnt about the Moon, its relief, motion in the sky...
- the pupils build a questionnaire for the adults to test their knowledge
- They can use the XO tools to analyse the results of the test (XO utilities: Sugar / Activity > Analyse

8 - Earth-Moon distance

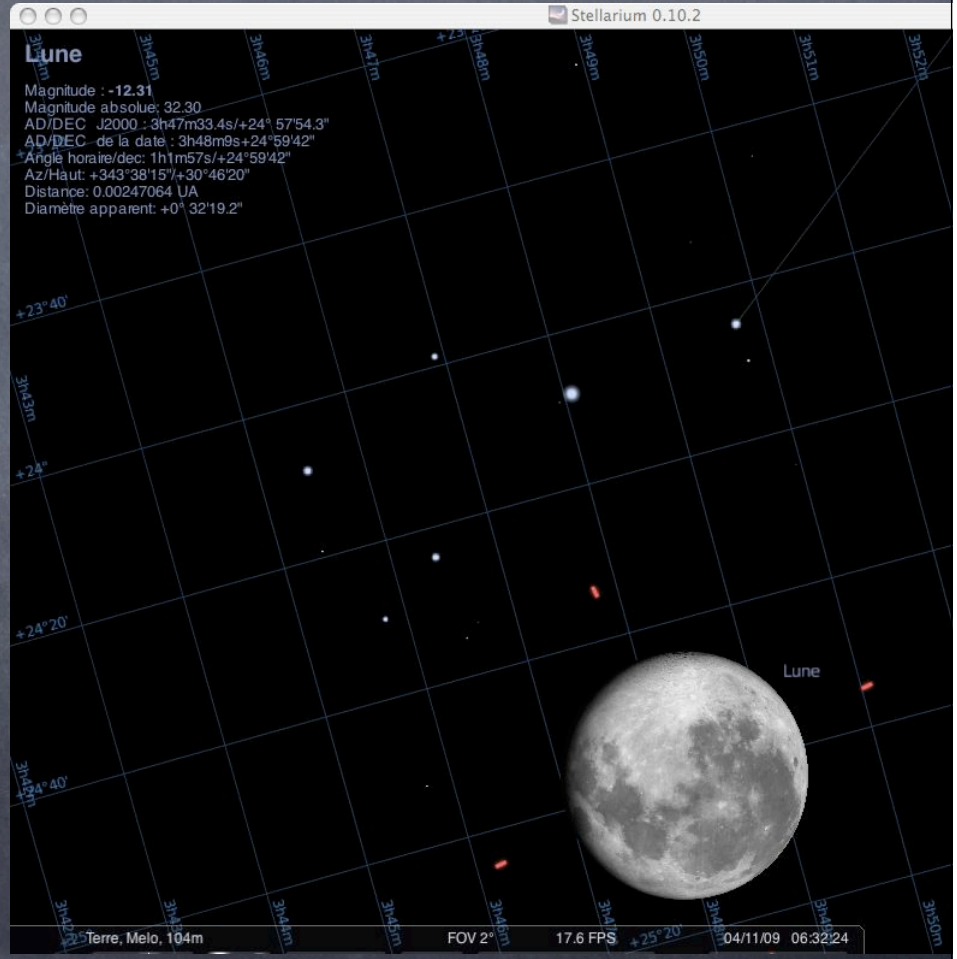
- International and collaborative project (La Main à la pâte - coordinated project)
- Synchronised observations from 2 (or more) distant locations on Earth. (Moon-bright star or Moon-planet conjunction)
- Based on parallax effect
- Simulation: build an Earth-Moon model
- Measurement of Moon-star positions and separation, exchange with partner through Internet. Analysis, comparison and simplified calculation based on the Earth-Moon modelling (through angles measurement)

In practice…

France



Uruguay



9- Sizing the Moon diameter

- Images of a Moon-eclipse
- Analysis: Comparing the size of the Earth shadow projected onto the Moon surface
- Simulation: reproducing the shadow cone formed between Earth and Moon