



Planetarium presentation: abstract for teachers

- Black text** basilar concepts and topics (*within the 60 min presentation*)
- Green text** additional concepts and topics (*extra the 60 min presentation*)
- Italic** direct references to research project activities (es. 3D models)
- Underlined** technical features to be adapted to each planetarium

1. Topic ONE: what is a planetarium. Why we should look at the sky. The horizon.

- Welcome under the dome. What is a planetarium. Why we need a planetarium: seeing celestial objects at any time, with every weather, seeing celestial motions at any rate, seeing skies from different locations of the Earth.
 - Why the planetarium is dark: eyes have to adapt to darkness. What we will see: stars and celestial objects visible to the naked eye.
 - Why observing the sky is important: keeping time, positioning and navigation, learning about geometrical and mechanical features of Earth and Solar System objects.
 - We are in a geocentric, i.e. “what we see from Earth”, perspective. The celestial sphere model. *We “enter” the bottle globe, and in this way we pass from an allocentric point of view to a geocentric POV.*
 - Apparent vs actual motions: we are on a moving object so it is difficult to discriminate between the two kinds of motion (we are not inertial observers)
- (QUESTION 1)**
- First reference line: the horizon as the “visibility” line. Ideal vs real horizon.
- (QUESTION 2)**
- Another reference point: the *zenith*, our vertical direction

2. Topic TWO: apparent diurnal motion of Sun and stars: rotation of the Earth and its axis' orientation (15 min)

(QUESTION 3)

- The Sun does not rise exactly in the same point each day but it rises in a well defined part of the horizon. The rising point of the Sun changes every day in a yearly pattern.
 - Solstices (= days “at the edge” of the rising zone of the horizon) and equinoxes (= days “in the middle” of the rising zone of the horizon).
 - The Sun’s path on the celestial sphere: Sun’s path is a circle, starting from its rising point in the eastern horizon and ending in its setting point in the western horizon. Height of celestial object as an angle. Sun’s path is not the same during the year (we will see it better later): how does it vary?
- (QUESTION 4)**
- The culmination point of the Sun: different height during the year but same direction. The cardinal direction South. The other cardinal points are defined from the South.
 - The culmination point divides daylight time in two halves: midday.
 - The shortest shadow identifies N-S direction and midday: solar clocks.

- Rising and setting points are opposite with respect to the North-South line. Since also the culmination point varies day by day the Sun's path changes in length during the year (the Sun's path has to pass through all these three points).
 - Apparent speed of the Sun is almost constant so paths of different lengths are covered in different amounts of time: we have different daylight time during the year (seasons).
 - Culmination height, daylight duration and insolation: causes of the seasons (geocentric reference system).
 - The motion of the stars: the stars move all together, with no noticeable motion with respect to one another: we see the whole sphere rotating with everything in it, *just as we rotated the bottle globe*.
- (QUESTION 5)**

- The motion of the stars is like the Sun's one both spatially (rise in the eastern horizon, culmination toward South, set in the western horizon) and temporally (it takes about 24 hours):
- (QUESTION 6)**

- Earth's rotation: we see Earth moving, not stars or Sun (merry-go-round analogy: relativity of motion).

- **Apparent diurnal motion = Earth's rotation**

- Apparent diurnal motion is not a definitive proof of Earth's rotation but it is a strong hint: we need other proofs.

(QUESTION 7)

- We are able to identify throughout the stars the axis of rotation: circumpolar stars toward the northern horizon.
- Polaris is "almost fixed". Celestial North Pole. Importance of Polaris as a benchmark of CNP (unlike CSP)

3. Topic THREE: figures in the sky and constellations.

- It is not easy to navigate the sky (e.g. to find a precise star) without any reference point: we have to find a simple method to rapidly find given stars and objects.
- We observe that stars do not have any detectable (for a brief amount of time) motion with respect to one another, so we use stars to "draw" figures in the sky and more easily remember their reciprocal position.
 - There are no actual lines in the sky: it is possible to draw different figures with the same stars.
 - Asterisms are typical of each culture.
 - Constellations are used to identify precise areas in the sky.
 - IAU selected 88 constellations to cover all the celestial sphere and to be used without ambiguities in international context.
 - Each constellation defines an area of the celestial sphere: IAU officialized *boundaries* of the constellations, not lines or figures, hence called "asterisms".
 - Main constellation of the current season.

4. Topic FOUR: apparent annual motion of the Sun: revolution of the Earth

- We observe that in each month we see different constellations setting immediately after the Sun in the same point of the horizon.
- We reconstruct, via star maps, the starred background of the Sun: **we see that the Sun moves with respect to the "fixed" stars.**
- Relationship between visibilities of Sun and stars: why we do not see stars by day. Atmospheric scattering. Sun and stars both move on the celestial sphere. Only in a planetarium can we see the Sun and stars at the same time.
- Sun always remains on a line wrt to fixed stars: the ecliptic. The Sun returns on the same starred background after a certain amount of time: the sidereal year. After a sidereal year, we are in the same position with respect to the Sun and stars: Earth has completed an orbit around the Sun. **Apparent annual motion = Earth's revolution.**
- The ecliptic is the intersection between the celestial sphere and the ecliptic plane.
 - Direct annual motion: from West to East. Reverse annual motion: from East to West
- We follow the annual motion of the Sun by the constellations crossed by the ecliptic (which are thirteen): the zodiacal constellations.
- Earth's motions are not separate: they occur at the same time
- Culmination height, daylight duration and insolation as a function of the Sun's position along the ecliptic: the seasons (geocentric perspective)

5. Topic FIVE: how to position and navigate on Earth looking at the sky: the observer position

- We can put each point of the Earth' surface in univocal correspondence with points on the celestial sphere: we can navigate on Earth by looking at the sky.
- We project reference points and lines on Earth of the geographical grid on the celestial sphere:
(QUESTION 8)
- Position of the observer = zenith
- North Pole = celestial North Pole
- Main meridian = local meridian
- Equator = celestial Equator
(QUESTION 9)
- Latitude can be directly seen on the celestial sphere: it equals the height of Polaris (in the northern hemisphere) because both angles are complementary to the same angle (angle between Polaris and zenith, called co-latitude).
- Traveling south we see new stars (never seen before) appear on the southern horizon, all having apparent diurnal motion: traveling north we see visible stars disappear.
- Height of Polaris increases traveling north and diminishes traveling south: at the Equator Polaris is laid on the horizon, and it is not visible in the southern hemisphere. At the north Pole Polaris coincides with zenith.
- The star trails inclinations (i.e. the angle they form with the horizon at the star rise) changes with latitude.
- Sun's path changes inclination with latitude too, but it also changes in length, as previously described, at each latitude
- We thus see that through stars we can always find our position on Earth and, guided by stars, be certain to come back home.

QUESTIONS:

1. **QUESTION 1: What is "still" with respect to you in the two different systems?**
ANSWER 1: In the bottle globe (allocentric view) the Sun, stars and celestial bodies are still wrt to you
In the planetarium (geocentric view) the Earth, i.e. you, is still.
2. **QUESTION 2: What dome feature represents the horizon?**
ANSWER 2: The dome feature representing the horizon is its *edge*, because it is the line from which we see celestial bodies appear
3. **QUESTION 3: Where will the Sun rise tomorrow? Same point or not?**
ANSWER 3: No, the Sun will not rise in the same point
4. **QUESTION 4: What stays constant in the Sun's paths throughout the days?**
ANSWER 4: What is constant is the direction of the culmination point
5. **QUESTION 5: Which other celestial body does the same motion?**
ANSWER 5: the Sun: it rises in the eastern horizon, culminates towards the South, sets in the western horizon
6. **QUESTION 6: Why do different objects make the same movement?**
ANSWER 6: Because it's not them who rotate, it's us, so that we see our motion, not theirs.
7. **QUESTION 7: Which is the only fixed point (or line) in Earth's rotational motion?**
ANSWER 7: It's the axis of rotation
8. **QUESTION 8: Where are the *position of the observer, NP, meridian and Equator* projected in the celestial sphere?**
ANSWER 8: as below:
 - Position of the observer = zenith
 - North Pole = celestial North Pole
 - Main meridian = local meridian
 - Equator = celestial Equator
9. **QUESTION 9: Can latitude be read on the celestial sphere (without reference circles?)**
ANSWER 9: Not directly: we need to find a proxy for it



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