PRACTICAL EXERCISES FOR PUPILS

Name of the activity	Supposed time demandingness	Difficulty of the activity	Suitability for the age group	Tools and necessary materials	Objective of the activity
Distances and sizes in the Universe	20 – 30 minutes	Simple to medium difficult	13 – 15	encyclopaedia, star charts or internet/computer software such as Stellarium/Star chart, calculator	Reminding of typical distances and sizes of spatial objects, simple calculation of various distances
Balloon model of expansion of Universe	20 – 30 minutes	Medium difficult	14 – 15	Rubber balloon, felt-pen (or self-adhesive decoration stars), paper/tape measure, calculator	Modelling of expansion of Universe and determination of the distances within
Model of Orion constellation	1 – 2 hours	More time demanding, depending on the precision of the realisation	13 – 15	Bamboo stick, paper, glue or adhesive tape, tape measure, coloured paper or crayons/felt-pens, glue, polystyrene board, internet or computer software such as	Creation of three-dimensional constellation model, stars within ate not in the same distance from us

				Stellarium/Star chart	

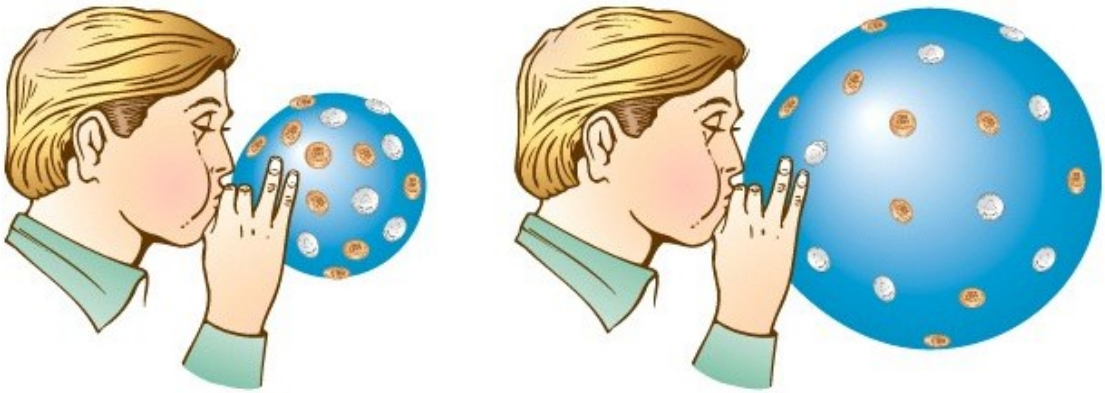
Practical Exercise 2: BALLOON MODEL OF EXPANDING UNIVERSE

Objective of Practical Exercise: create a model illustrating the expansion of the Universe

Tools:

- Rubber inflatable balloon,
- Felt-pen (or self-adhesive decoration stars),
- paper/tape measure,
- calculator.

It is not evident at first sight that the Universe should be expanding. The size of a classroom or a school does not change and neither do the distances between the places on Earth. But is does apply to big distances – distances in the Universe (at least some of them) do increase. In the 20-ties of the previous century, the American astronomer Edwin Hubble discovered that almost all galaxies recess from our Milky Way. However, it does not mean that our Galaxy should be a centre of the Universe.



Model representing the expansion of the Universe by means of an inflatable balloon.
Source: https://astronomy.stackexchange.com/questions/17965/is-the-universe-moving-through-infinite-space-time-as-it-expands

Instructions:

1. Work in pairs or triplets.
2. Blow the balloon up to a diameter of cca 10 cm. Hold the end tight with your hand so that the air will not escape, do not tie it up.

3. Use the felt-pen to make six marks on the balloon, one of them name G (for our Galaxy), the other mark by numbers 1 – 5 (denoting other galaxies in the remote and young Universe). Be careful not to do the marks in one line!
4. By means of a paper or tape measure gauge the distances d_1 from G „galaxy“ to other marks 1 – 5 and write them in a table as a Measurement 1. Be careful not to let the air from the balloon escape. Use the tape measure to determine the circumference of the balloon in its widest part.

5. Blow the balloon up again until it doubles it size (i.e. up to 20 cm in diameter).
6. Measure the distances d_2 of G„galaxy“ to the marks 1 – 5 and the circumference of the balloon in its widest part and write it in the table as Measurement 2.
7. Once again, the last time, blow up the balloon until it is 30 cm wide.
8. Measure the distances d_3 of G„galaxy“ to the marks 1 – 5 and the circumference of the balloon in its widest part and write it in the table as Measurement 3.
9. Calculate the differences $d_2 — d_1$ and $d_3 — d_2$ for each of the marks 1 – 5 in the last columns of the table.

Measurement:

Distance from the G„galaxy“/cm	**Measurement 1 d_1/cm**	**Measurement 2 d_2/cm**	**Measurement 3 d_3/cm**	**Difference (d_2 — d_1)/cm**	**Difference (d_3 — d_2)/cm**
Mark 1					
Mark 2					
Mark 3					
Mark 4					
Mark 5					
Circumference of the balloon/cm				X	X

Final questions:

1. How did the distance from the G „galaxy“ to the remaining marks 1 – 5 change after each blowing up of the balloon?

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2. Which marks did recess more - the ones that in the beginning were closer or further away from the G?

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3. Let us say that the blowing up of the balloon takes always the same time t (e.g. 10 s). From the differences $d_2 - d_1$ and $d_3 - d_2$ it is possible to calculate the „speeds“ of recess $v_1 = (d_2 - d_1)/t$ and $v_2 = (d_3 - d_2)/t$ (our speeds are small, but for the galaxies in the Universe we get them in km/s!).

	Speed $v_1 = (d_2 - d_1)/t$ in cm/s	**Speed $v_2 = (d_3 - d_2)/t$ in cm/s**
Mark 1		
Mark 2		
Mark 3		
Mark 4		
Mark 5		

Do the speeds depend on the distance d1? If it is the case, how?

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