Publ. Astron. Obs. Belgrade No. 86 (2009), 241 - 246 *Contributed paper*

ASTRONOMY IN THE FRAMEWORK OF PHYSICS TEACHING IN PRIMARY SCHOOLS IN SERBIA

M. BRACIĆ
Primary school "Vuk Karadžić", Ulica 16, 23000 Zrenjanin, Serbia
E–mail: bracicm@zrlocal.net.yu

Abstract. Astronomy on a daily basis provides an ever increasing amount of information about the Universe. This information is attractive, it reveals to us new worlds and broadens our mental and cultural horizons. Astronomy is very interesting for the pupils of primary schools. However, unfortunately, primary school curricula do not contain enough astronomy topics. As physics and astronomy are compatible, it is only natural that physics lessons should include many astronomical contents. Nowadays, the share of astronomy in physics lessons is very modest. The modern discoveries are not even mentioned. In teaching physics one can use many examples from astronomy or astrophysics. In this way the pupils' views would be broadened, and their picture of the world richer.

1. INTRODUCTION

Matter comprises all things that exist in nature. It is in the continuous motion which gives rise to its changes. These changes take place over seven structural levels - those of elementary particles, atomic nuclei, atoms, molecules, macroscopic bodies, large scale structures and that of the universe itself.

On the primary-school level pupils get an elementary knowledge about the core structural levels of matter, from protons, neutrons and electrons, via atoms and molecules, to the Solar System bodies. Atoms and molecules are topics of dedicated lectures, but make part of many others as well. In the eighth (final) class several physics lectures are devoted to the atomic nucleus. Molecules are treated in more detail in the lessons of chemistry. Micro and macro world accessible to our perceptions are also thoroughly treated. The attention of the primary-school pupils is mainly oriented to the objects and phenomena from their immediate surroundings.

Stars, black holes, white dwarfs and pulsars are not included in the primary-school program; galaxies are only mentioned. The pupils have no idea about the distances to various celestial bodies, they do not know what are the distances to the closest stars beyond the Sun, and are even unaware that the Sun and stars are of the same nature.

Through media pupils are informed about other worlds, that is about other structural levels of matter. Intertwined with their imagination, this information creates great interest in micro- and macro-worlds. All this attracts them, becoming the source of many questions on which they seek the answers. It is sometimes enough just to

mention atoms, quarks, pulsars, supernovae, black holes and galaxies to catch their immediate attention.

In the era of space exploration and the discovery of extrasolar planets, when the human knowledge expands at a great pace, all this progress should be conveyed to pupils in a simple and systematic way. They still have no prejudices and firmly founded attitudes which could limit their understanding of the world. The mind of a child is open and free, and it should not be underestimated. Instead it should be duly stimulated so that they can achieve a proper understanding of the nature.

2. ASTRONOMY IN THE PROGRAMS OF PHYSICS: CURRENT SITUATION

Every solar eclipse can be observed either with a small telescope or with simple auxiliary equipment. Such an event is attractive enough even to the parents who can be helpful in the organization of the observations. The phenomenon can be analyzed in the multidisciplinary sense, from the point of view of physics, astronomy, chemistry, biology, geography, informatics, mathematics, art and culture, etc.

The August 11, 1999 solar eclipse was observed by a group of 50 pupils of the VIth, VIIth and VIIIth class from several schools in the town of Zrenjanin. In addition to physics teachers those teaching biology and informatics were also engaged. Pupils measured the variation of air temperature, pressure and humidity during the eclipse, the change of speed and direction of the wind and light flux. They also projected the image of the Sun on a screen, observed the behavior of domestic animals, birds, frogs and lizards in the school terrarium, measured their own blood pressure. They recorded their observations and results of the measurements, analyzed the complete material afterwards and made it available on the corresponding site. Part of this material was also presented at an exhibition of drawings and paintings of the pupils in a local gallery. The name of the exhibition was "Eclipse impressions". The teachers presented this work at a national seminar devoted to teaching of physics and at a few more occasions. The data reduction and analysis of the material lasted for several months. The motivation of both teachers and pupils all the time remained high, while the parents offered important assistance in purchasing and transport of the necessary equipment. Some of them, who happened to be the experts in some fields, provided additional information and assistance. Till the 1999 eclipse, the Sun was perceived as an ordinary celestial phenomenon to which we were accustomed paying no attention. After the eclipse our awareness of its presence grew so that we became more familiar with it. Having this didactic and pedagogical experience, we organized observations of partial solar eclipses, as well as of the lunar ones. The pupils were appropriately prepared for each of them. The observations and images taken during the eclipses were regularly reduced, systematically analyzed and presented.

When the transit of Mercury over the solar disc was observed, the experience acquired during the observations of the solar eclipse was employed. In such a case teacher is rather a coordinator, partner or adviser encouraging the pupils to act independently. This activity involved several primary schools, both teachers and pupils.

The very attractive recent transit of Venus was observed with two telescopes. With one of them the image of Venus against the solar disc was projected on the screen attached to the telescope. Thus, a large number of pupils could simultaneously observe

and register the phenomenon. This telescope became focus for visitors, pupils of other schools and passers-by who gathered around it. The pupils talked with these people about the transit and answered the questions. Pupils of the first class who came with their teacher to see the phenomenon, expressed the impressions on their drawings, thus giving a special flavor to the event. At the other telescope a filter was used, the phenomenon was directly registered by a camera and the obtained photos were used to create an animation. The event was thoroughly covered by the local press and electronic media. This additionally motivated the pupils, as this gave them a feeling that they were participating in an important event.

A physics teacher can make use of the preparation for any of these activities as an opportunity to make the phenomenon known to the pupils, to explain them its nature and how and when it takes place. Trained and well-informed pupils can observe it at their homes by themselves or with their families. In this way the skills necessary to observe astronomical phenomena are mastered by many people.

The Summer School of Physics organized at Palić has within seven years been attended by almost 500 pupils and 70 teachers. The programmes contained a significant fraction of astronomical topics. Every day sunspots were observed on a screen and registered, and a report was presented to all pupils. By night pupils were becoming acquainted with constellations and the orientation using stars, so that soon they were able to find constellations in the sky. Well known objects in constellations were introduced to the pupils by means of a telescope or through photographs. By using the telescope every day the pupils learned to manipulate the device. To the majority of pupils this was the first contact with an astronomical instrument and astronomical concepts. A special activity was to see and analyze a science-fiction movie where the task for the pupils was to evaluate the scientific background of the story to distinguish pure fiction and material errors from the scientifically established facts.

As a nice summary of all these activities let us mention that one of the pupils concluded that "the stars do nothing for a human being unless she/he gazes at them".

The present experience and results achieved by pupils, both in teaching natural sciences and in the interdisciplinary understanding of natural phenomena, give the astronomical contents in the programs of physics an important place in the education at the primary-school level. This requires an intensive engagement not only of enthusiastic teachers and some pupils, but also the participation of a local and wider educational community, so that more people benefit from these activities.

3. ASTRONOMY IN THE PROGRAMS OF PHYSICS: PROPOSALS FOR THE FUTURE

To teach physics nowadays one needs a computer, possibly with graphics card to connect it with TV screen to establish a visual contact of pupils with the course content. This can be easily achieved by locating TV screens at visible places in the classroom. Today, we have plasma and LCD screens providing larger and better images.

The computer can be connected to the Internet. The subject of a lesson can be traced on the web to extend the information, give more explanations and possibly see an animation, video clip and the like. What's up in Space on that day can be found at http://www.spaceweather.com. The appearance of the Sun for each day can be seen at http://sohowww.nascom.nasa.gov.

The teacher makes the presentation containing a current lecture, repetition and improvement of understanding of earlier lectures and checking the pupils' knowledge. These presentations with adjustments and updates can be used again in the years to come. A pupil more easily comprehends the visual information on the topic which is to be learnt or the problem to be solved because in this way they are more clearly formulated (50% of knowledge is acquired visually).

In all the segments of the teaching process, the teacher can make use of the astronomy and astrophysics examples. In this way the children's knowledge expands from terrestrial dimensions to the global ones, those of the Universe, thus broadening their view of space, time and of various forms and manifestations of matter.

In the introductory physics course, in the sixth class, when the nature as the subject of physics is presented (physics was named after nature), one can show planets, stars and galaxies. There is no need to limit oneself to the examples from the Earth's nature only (plants and animals, rivers and oceans, clouds, thunders and lightnings, etc). Astronomy offers a variety of examples, illustrated with spectacular photographs of Solar System bodies, as well as those showing distant objects such as nebulae, birthplaces of stars, star clusters and galaxies, etc. In such a way children become aware of the nature that supersedes their common perceptions. Photographs of spacecrafts, satellites, orbiters and rovers show to the children how far has man accomplished in the space exploration, what are his capabilities, what are the consequences of the development of science and all this directs them to their future professions. Their imagination is stimulated and the curiosity yields a strong motivation towards research.

In the teaching process, questions like the following ones can be used.

Example 1: What is the consequence: (a) Rotation, (b) Day and night?

In this example one can show on the screen a photograph of the Earth with the terminator.

Example 2: Incomplete, sometimes erroneous notions are obtained by applying: (a) only observations of apparent motions, (b) observations and their interpretation in terms of relative motion.

In this case one can show the Ptolemaic geocentric model of the Solar System which is based on the observations of apparent motions.

When the motion of bodies is to be explained, in addition to examples of everyday motions on the surface of the Earth one can also use examples of the motion of planets, comets, spacecrafts, or of the rovers Spirit and Opportunity on the surface of Mars, etc. For understanding of the relative motion and of the state of rest useful examples are the Sun and planets as origins of reference frames.

A pupil of this age can perceive objectively and realistically the speed of her/his motion as a pedestrian, on a bicycle, in a car. The speeds attained by a Formula 1 car, a cheetah, or an aeroplane may seem attractive to her/him, but they remain speechless when they learn the speeds of motion of the Earth, the Moon, the Solar System. To ensure the pupils get an idea of different speed scales one can mention the speed of the Earth's rotation and revolution, the velocity of the Moon orbiting the Earth, of artificial satellites (orbital speed, escape velocity), of the Sun around the galactic center and so on, ending up with the speed of light. A pupil need not to

memorize this information, this is rather a way to make him comprehend the scales in order to overcome the limits imposed by her/his immediate experience.

The distances between planets, stars and galaxies are at first inconceivable to the pupils. When they are told that the Hubble Space Telescope (HST) sees as far as 10 billion light years, their first consideration is that of the time, however they understand soon enough that this is a distance in space. It can be noticed that adults usually need more time than the pupils to perceive such large distances. Deprived of any frames, habits and prejudice the pupils adopt these concepts rather easily.

When mutual gravitational interaction, the gravitational force and weight are taught, one usually gives examples from our immediate environment present in the physics textbooks. Sometimes, only informatively, one makes use of the gravitational attraction of the Earth and the Moon, the Sun and the planets. However, here one can include also the examples of gravitational interaction of very massive stars, black holes, galaxies (appropriate illustrations can be found on Internet). All this is very stimulative for the imagination of the pupils.

In the following we present some examples.

Example 3: The Milky Way galaxy was formed due to: (a) Electric field, (b) Gravitational field, (c) Magnetic field.

The image of the Milky Way given in the background results in various associations among the pupils.

Example 4: Aboard the International Space Station (ISS) a water drop upon the surface of a leaf: (a) Produces a pressure, (b) Produces no pressure.

In the background there is a photograph of a clover leaf with water drops upon it taken aboard ISS.

Example 5: The mercury column in Torricelli's tube on the lunar surface would: (a) Descend to zero level, (b) Ascend to the top of the tube, (c) Keep the same level as on the Earth.

In the background a photograph of an astronaut standing on the lunar surface can be shown together with a schematic presentation of Torricelli's tube.

In the treatment of Newton's first law of dynamics space phenomena can be useful. For example, the motions of nearby stars due to the enormous distances seem as if they were uniform and rectilinear.

In the case of acceleration (Newton's second law) we have a good example in close encounters of celestial bodies, for instance the instantaneous interaction of two bodies resulting in an abrupt change of their original orbits.

In the case of Newton's third law the example of rocket propulsion is well known. Also, the use of a cable to tie the astronauts to the spacecraft when they exit to the open space is very illustrative.

Example 6: Most of the time spacecraft moves without spending fuel due to: (a) Inertia, (b) Gravitational force, (c) Magnetic force.

A photograph of the ISS can be in the background.

Example 7: An astronaut can be pushed away of the spacecraft due to: (a) Friction, (b) Action force, (c) Reaction force.

In the background a photograph of an astronaut by the ISS is given.

In the presentation of gravitational fields the examples can be the Earth-Moon interaction, possibly also with the Sun. The surface gravity for various bodies can be compared in terms of their masses and radii. In this context one can also mention the black holes, galaxies, gravitational lenses. The pupils should be familiarized with the fact that the force of gravitation determines the motion and the shapes of all celestial bodies.

The knowledge of the pupils can be checked by employing questions and exercises with astronomical contents. For instance, the task can be to compute the weight of a small test body or its free-fall path per unit time on different celestial bodies (like the Earth, Moon, Mars, Titan, etc.).

There is, practically, no lesson in elementary school physics which cannot be enriched with examples from astronomy. This holds even more for extracurricular activities, because in their organization a teacher of physics is free to include as many topics of astronomy and astrophysics as he/she finds appropriate in order to meet the needs and desires of the pupils.

References

Ivić, I., Pešikan, A., Antić, S.: 2001, Aktivno učenje, Institut za psihologiju, Ministarstvo prosvete i sporta Republike Srbije, Beograd.

Kapor, D. V., Šetrajčić, J. P.: 2003, Fizika za VI razred osnovne škole, Zavod za udžbenike i nastavna sredstva, Beograd.

Naumovski, K.: 2000, Sazveždja severnog neba, Zmaj, Novi Sad.

Šetrajčić, J. P. , Kapor, D. V.: 2005, Fizika za VII razred osnovne škole, Zavod za udžbenike i nastavna sredstva, Beograd.

Vukićević-Karabin, M., Atanacković-Vukmanović, O.: 2004, Opšta astrofizika, Zavod za udžbenike i nastavna sredstva, Beograd.