Presentation of some untraditional experiments and understanding of the essence of physical phenomena

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Some considerations at the beginning

Nowadays effort exerted at the universities for teachers of physics will be reflected in some years later. Difficulty, structure, forms and a content of their preparation should lean on the fact, that the gained knowledge, skills, styles of work the way of communication, ability to work with information are going to be presented by the nowadays graduates in three, five or more years later in their pedagogical praxis.

Many times you can hear about the „crisis“ in the educational process concerning physics [1], about the lack of interest in physics among the students [2], about insufficient appreciation of the meaning of the physical education for the next social development. It seems to me like an „vicious circle“. Teacher standing in front of pupils who are without concern and interest in physics and education in natural sciences at all, is often without work enthusiasm.

The teacher generally face undignified appreciation of their profession, bad working conditions and social non-appreciation of their laborious work. The society meets with the aversion and feeling of uselessness of the physical education for the needs of practical life. We become observer of the decrease of the interest in physics as a study branch and as a science discipline. It is high time to cut this „vicious circle“.

The principal course of physics provided for the students in the present times, has its historical routes in the period of some last decades. In those times the presented physical phenomena „moved“ with the science and technology, they inspired and attracted wide public. The way of presentation of basic physical phenomena comes nowadays many times out of the historical form. In the minds of nowadays young people are settled the most modern conquests of the science and technology, about which they gain only superficial or consumptive information. That what could be of their interest in the physics stays out of school benches or follows after huge amount of - for them unattractive - physics.

Material-technical, experimental and demonstrative equipment of the schools remains behind and does not suit for the basic principles of the information society. A student gains the idea about the physical problems mostly at the theoretical level and he is very often not able to identify with physical knowledge, that he does not know from his own practical experience. He is able to reproduce the gained knowledge but his own consideration about the problem is at the level of very simple and many times incorrect analogies from life. Student copies only the outside cover and does not understand what is inside. He is able to speak about the well-known facts but he is not able to apply them in untraditional conditions and to contribute with something special and new. The absence of the experimental recognising activity while adopting the physical knowledge markedly participates in the incomprehension of the substance of the physical phenomena and consequently also in the lack of interest of the students in physics.

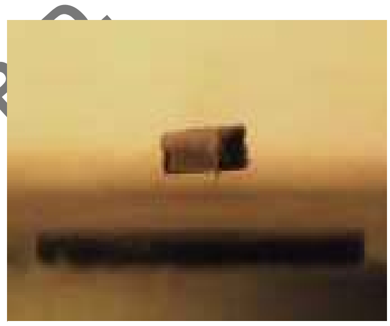
The up-dated understood preparation of the next teachers of physics has to be interesting and prospective for the students, it should be based on their own interests and on their creative approach, it has to include the elements of the information society, for which the students are prepared.

Examination of the physical phenomena by means of demonstration experiment

In my opinion the computer, multimedia or audio-visual technology nowadays could not substitute the real physical experiment, not even the student’s experiment. On importance of the own creative activity of the student, while gaining the knowledge, was pointed out in the work of J. A. Komenský [3]. I submit two untraditional experiments of the students, that could become stimulative for the other students of physics by means of method of the independent realisation and directed physical interpretation. These experiments could provide them pleasure from discovering of physical phenomena and understanding of their essence.

Meissner´s effect

The results in the field of physics of high-temperature superconductors known in the last period are going to serve for practical and effective usage. Because of their interesting presentation a student has a possibility to realise experiments by means of a set produced by Can Superconductors.

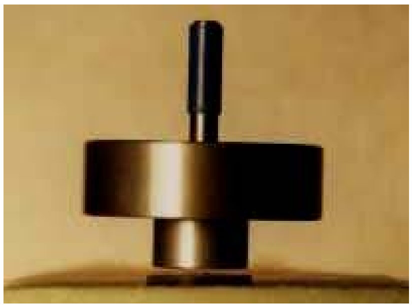


Picture 1. : Meissner`s effect

W. Meissner and R. Ochsenfeld discovered in the year 1933, that placing the superconductor in the magnetic field and cooling it off under the temperature of transition in the super-conductive state the originally present magnetic flux is pressed out from the sample, the superconductor behaves as an ideal diamagnetic with a magnetic induction in the inside of the sample that equals zero. This physical property of superconductors is called Meissner´s effect (See picture1).

Meissner´s effect could be observed only in a weak magnetic field. In case high-temperature superconductors - that are belonging to superconductors of the second type and are conductive in a strong magnetic field - are used, the situation is rather more complicated. The strong magnetic field is pressed out only partially and one part of the magnetic flux penetrates in the superconductor. The demonstration of the pressure out of the magnetic flux by means of high-temperature superconductors is easy and popular because as a coolant for fast chilling of the superconductor under its critical temperature would be enough the liquid nitrogen.

By means of this above mentioned set students demonstrate levitation of a small magnet of rare soils above the high-temperature superconductor, caused by the partial pressure out of the magnetic flux from the volume of the superconductor.



Picture 2. : Demonstration of the great levitation force

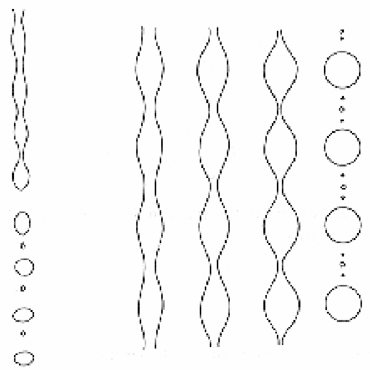
It enables the students to observe great levitation force of the permanent magnet above the superconductive levitator (See picture 2) and to present the application of the high-temperature superconductors in magnetic bearings. In this case the levitation force is not based on Meissner´s effect but on strong seizure of the stronger magnetic flux inside of the superconductor.

In case of the superconductors of the second type can the strong magnetic field penetrate in the volume of the superconductor and be seized on the defects and grain boundaries of the crystals - so called seizing or pinning centres. If the superconductor is cooled under its critical temperature in the outside magnetic field - e.g. near the permanent magnet - the magnetic flux caused by magnet will be seized in the superconductor. Then both the attractive and repulsive forces will hinder in the change of mutual position of magnet and superconductor.

It is an easy demonstration of the superconductive magnetic bearing without friction, which physical principle could be used e.g. in flywheel systems for accumulation of energy.

Stroboscopic observation of a spring of water

You have been surely observing many times a spring of water coming out from the waterspout. Do you know how much physics is hidden in it ? By observing with a loose eye we have found out that a spring of water is „spreading“ and becomes „blur“. We have seen this phenomena many times.



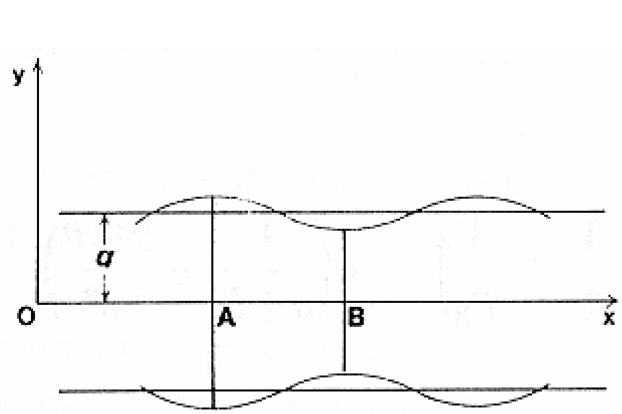
Picture 3. : Spring of water under strobocopic light

Now have a look at the spring of water by using a stroboscope (See picture 3). Let us consider a cylindrical flow of water coming out from round waterspout. The instability of the flowing spring of water can be explained by the changes of the pressure in the flow of water. The illumination of the flow of water by a stroboscope and setting of the proper frequency of blinking allows us to observe in the lower part of the water flow independent flowing drops of water. It is a fascinating view that could not be seen without the stroboscope because of the eyes inertia. The physical reason of this phenomena is following.

Let us consider cylinder of flowing water with a radius *a* (See picture 4). The cylinder is deformed through the activity of small periodical impulses with their wave length □ and is gradually changed from

$$y = a \qquad \text{to} \qquad y = a + b \cdot \cos\left(\frac{2\pi \cdot x}{\lambda}\right) \qquad (1)$$

$$\text{where} \qquad b \langle\langle a$$



Picture 4. : Cylinder of flowing water

Spring of water is stable if in the area with a greater cross dimension (A) is a pressure higher than in the area with smaller cross dimension (B). The liquid flows in the water flow from the area with a higher pressure in the area with a lower one and tries to preserve cylindrical shape. For the determination of stability conditions we have to apply Laplace-Young equation. In the arbitrary point of the area A is the radius of a curved surface R_1 and R_2 which are going to determine the pressure. R_1 is a maximum radius of a cylindrical surface: R_1 $=a+b$

R_2 is given $$R_2 = \frac{\left[1+\left(\frac{dy}{dx}\right)^2\right]^{\frac{3}{2}}}{\frac{d^2y}{dx^2}} \qquad (2)$$

We take into consideration small deformations $\frac{dy}{dx} \langle\langle 1$ it means $R_2 = \frac{1}{\frac{d^2y}{dx^2}}$ (3)

By means of differentiation process (1) and (2) we obtain R_2 in the point of maximum cross dimension:

$$\frac{1}{R_2} = \frac{4\pi^2 b}{\lambda^2} \qquad (4)$$

The pressure in the area A is greater than the outside one by a :

$$\sigma\left(\frac{1}{R_1}+\frac{1}{R_2}\right) = \sigma\left(\frac{1}{a+b}+\frac{4\pi^2 b}{\lambda^2}\right) \qquad (5)$$

similarly in the area B is the pressure difference comparing the outside pressure

$$\sigma\left(\frac{1}{a-b}-\frac{4\pi^2 b}{\lambda^2}\right) \qquad (6)$$

If we neglect the gravity of liquid , the difference of pressure between A and B is:

$$\sigma\left(\frac{1}{a+b}-\frac{1}{a-b}+\frac{8\pi^2 b}{\lambda^2}\right) = \sigma\left(\frac{8\pi^2 b}{\lambda^2}-\frac{2b}{a^2-b^2}\right) \qquad (7)$$

and $b\langle\langle a$, and he preceding formula is reduced to

$$\sigma\left(\frac{8\pi^2 b}{\lambda^2}-\frac{2b}{a^2}\right) = \frac{2b\sigma}{a^2}\left[\left(\frac{2\pi a}{\lambda}\right)^2-1\right] \qquad (8)$$

The pressure difference must be positive for the stable flow of water or soap film. It means:

$$2\pi.a > \lambda \qquad (9)$$

Fulfilling this condition any vibration does not cause tearing of the water flow into drops but the shape of water comes back to cylindrical form. The cylinder of liquid is unstable because of $\lambda \geq 2\pi a$ and also small breaks cause tearing into drops. Setting of this condition by means of regulation of the water flow is left on students. By the stable cylindrical water flow it is possible by means of proper tuning fork or loudspeaker laid on tone generator to cause the instability and the disintegration of the cylindrical spring of water into independent drops. A determination of the frequency for the origin of instability and its comparison with (9) and for the independent experimental finding out is left on students.

By means of these demonstration experiments I am following the trend of modernisation in the physics education, increasing of students' interest in physics and I support independent adopting of physical knowledge. The independent realisation enables the student possibility to approach creatively towards acquiring of knowledge, to create better understanding of the causes of physical phenomena and to remember it.

Bibliography:

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