USING A SYSTEMS APPROACH WITH THE VAV METHOD TO DESIGN AN INTRODUICTION TO ANTIMATTER FOR SECONDARY SCHOOL STUDENTS

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Abstract: *We continue the development of system design principles in the VaV method to illustrate their application to the design of a Teaching Point Set, TPS, for a specific theme that was chosen to meet the following criteria: "It is to be attractive as well as educational to diverse groups of secondary school students." The theme was chosen, and the corresponding TPS was developed in order to illustrate the original intention of the VaV method. The intention is to provide a formal and consistent framework for breaking away from textbooks in a way that guides the expression of the creative process, both for teachers and for students. Our second intention is to set a high standard for the systems design of TPSs with the VaV method so that this can be emulated and serve as a model.*

Summary: *A TPS, Teaching Point Set, to entertain and teach students about antimatter is developed and described. It contains eleven Stepping Stones, SSs together with their implied PaS, Point and Show, directions to further study, or discussion. We PaS to items such as semantics, critical thinking, speculative thinking (about the annihilation mechanism), and general education about classification and regulation of food. Each of the SSs contain something to do with physics, or with a type of reasoning important in doing physics. Each PaS section illuminates specific material in certain highlighted directions that link from its SS. It does this with appropriate Just Learned Knowledge, JLK, and reviews on helpful Recently Learned Knowledge, RLK. As a conclusion it is shown that the three Nobel laureates involved in the discovery of antimatter got their Nobel's for persistence on simple details in their simple quest to "just understand more fully"*

Key Words: *TPS, Teaching Point Set, SS, Stepping Stone, PaS, Point and Show, HoP, Hand over Phase, RLK, Recently Learned Knowledge, JLK, Just Learned Knowledge, readiness, preparedness.*

1.0 Introduction to the VaV Method

The VaV method, introduced in Ref 1, and discussed in Ref 2, is illustrated herein as a systems design methodology for a theme that,

a) is to be made interesting to diverse groups of secondary students, and

b) is to discuss, and maybe answer, the question, "What is antimatter?"

2.0 General Description of the VaV Method

VaV stands for Vstup and Výstup, (or Entry and Exit, in English). The VaV method is a systems approach that is based on the identification of relevant parameters to design SSs, and TPSs. It is applicable for selecting a set of appropriate teaching material that is over and above those given in text books. They can be used by teachers to bring special interests, and special topics to the students as their need or desirability arises. We call such teaching points developed for a special purpose a Teaching Point Set, TPS, while the subtopics comprising the TPS are called Stepping Stones, SSs (Ref 2).

2.1 The Variables

Our goal is to design a set of SSs for the TPS to accomplish the stated theme in accordance with a method called the VaV method which is based on an interplay between the following eight variables,

CT= (V,G,D ,W=((S,T),P,M, C)),

where:

CT = creative teaching, = (Values (V), Goals (G), Decision making methods(D), World background (W)). More precisely, we identify five main background parameters for the effective use of the VaV method as a system design tool for creative teaching:-

W = the (relevant) World Background state = (Students (S),Teachers(T),Parents(P),Ministry (M),Context(C)).

Notes

1) In general, in this paper, M stands for “matter” (not “ministry”), and AM stands for “antimatter”.
2) This paper illustrates how the author used the three variables, (V,G,D) to design a TPS satisfying requirements a) and b) above.

2.2 Discussion of the Variables

The first three (V,G,D) of the eight variables are readily changeable, at the discretion of the teacher. They are where the creative teaching comes from. They are the “free” variables, that allow for creative freedom. The other variables are relatively fixed for longer periods of time and are the givens of the system at least for the short term, as far as one particular TPS is concerned. A particular teacher’s (V,G,D) is more or less fixed in the short term also. But it can be changed at the teacher’s discretion by continued `study or preparation. Of the remaining five variables the VaV method focuses mainly on the pair (S,T):

S = Students. These come to us with a given readiness and motivation for a task or teaching sequence. We will not change these in a month (medium term), or usually not even a semester or two (long term), but the goal of creative teaching is to give students a more powerful start by influencing them through some creative and innovative TPSs and/or through creative designs of SSs. This change can also happen suddenly (very short term), or within a few weeks (short term).

T = Teachers and classrooms. Teachers have certain beliefs, interests, ideas, and expectations about the ideal students, about the role-model students, and the “in-norm” students, as well as ideas about the sufficient (good enough) teaching they are expected to transmit, and how classrooms are to be arranged, etc. Besides (V,G,D) other variables are understanding, and preparedness. The other identified variables are:

P = Parents and family life. Parental support, and expectations are most important as their influences can either resonate with those of the teacher (causing amplification of influences and of student self-based efforts to excel), or can interfere with them, and cause attenuation of intended teacher influences.

M = Ministry (Department) of Education. This provides and makes available resources, seminars, regulations, requirements and other types of support that the creative teacher can access.

C = Context. This is the additional relevant facts not included in those of (S,T,P,M) . E.g., context can be about a special competition, like helping students prepare for the TMF, Turnaj Mladých Fyzikov.

2.3 Selecting (V,G,D) for Creative Teaching of Physics

The creative teacher will work to

a) improve these three, (V,G,D), and

b) to use (V,G,D), in a creative fashion that interacts effectively with the other, more stable parameters that comprise the background, W, to the creative teaching design and delivery.

2.3.1 Identifying and Using the Value Set, V

This paragraph intents to show that of the three so called free variables of creative teaching, the values V are most important. Five general sorts of value subsets of V are presented for consideration by VaV practitioners.

V is the set of factors or outcomes that are regarded as valued or "good" in physics education. Note that this includes other things besides physics at the secondary school level. I.e., from the VaV point of view, physics education is not only about physics, but most importantly it helps develop good thinking skills about the real world in which we live, have our being, and in which we improve ourselves , our regions, countries and the very earth that gave us our evolutionary profiles. Thus the Values set, V is very large, and can be used only part by part, depending on circumstances (in the World Background, W). I.e., the values selected from the Value set V are not constant for the teacher and can be varied from semester to semester, or even from month to month, depending on, let us say, "the themes for the month".

Some examples of V subsets :

i) The goals of a TPS can be to make the students employable quickly, e.g., as soon as possible, after graduation from high school. E.g., they can be trained as reliable technicians who have skills in measurement of physical parameters, and know how to take care of instruments.

Depending on teacher and student interests, the teacher can bring into class special instruments that are not part of the given curriculum. These can also be selected based on new games, or toys that are to be analysed for their operating principles.

ii) The goals and values of a TPS can be about creative problem solving, even creative self-directed research of a general question, such as one or more of the open questions posed in the yearly TMF competitions that are described in the Turnaj Mladých Fyzikov (TMF), which offers participating students rich experiences for their future development opportunities. More can be found at the TMF site, http://www.tmfsr.sk/, as well as other sites. See Appendix A for an English version of the guidelines used to evaluate secondary school student's planned and executed project-based investigations

iii) A general physics education can help to develop good and self-thinking citizens. Physics can be used as an example of a type of scientific, precise thinking. Creative teaching can design TPSs to do just that from some sort of physics-related problem, question, or practice. Depending on student readiness, preparedness, interests, etc., the teacher can choose to emphasise, ordinary everyday observations that can be explained by physics, critical thinking skills, rather than detailed theoretical knowledge and the importance of observation/description. For example, the class can study apparent paradoxes or puzzles that appear contrary to common sense and common understanding as developed in young students and laymen who were educated long ago with ideas based on the previous paradigms and traditions.

iv) For promising and very interested students the TPS can be selected to stress the big ideas, the big news, the big unknowns (mysteries, paradoxes, etc.), in physics, important news, and the big achievements (even if they are not made into big news in the general media).

v) Depending on context, V can be selected as "increasing test scores". This is a rather common bureaucratic selection, even a requirement. It has its strong merits, but we need to note its weaknesses too. It accepts/assumes that the tests are "perfect measures" for the intentions of the education philosophy of the school, the school district, the region and for the student's progress. In fact, the tests are based on text books and so there is not much need to be creative there, except to increase student interest and self-constructive participation. This means that TPSs need not necessarily involve the material to be reviewed, but can involve other subjects. A more interesting and a more worthy task is to create special interest in the students, to motivate them in different ways such as described above so as to learn the text book material. On the other hand, that having been said, taking class time or homework time to assign extra problems based on previous test levels can be a worthy and creative endeavor, because it serves as a comprehensive review to JLK, or RLK. Seeing things a second time, and placed together within a short time span, can provide an "Aha!" moment, or its variants, "Oh!", "So that's the way it is!", "Now I get it.", "Got it.." etc.

2.3.2 The Decision Variables and System

The decision system, D, is used to pick what subset of V is to be used in the design of a particular TPS and its SSs. D can be very intuitive, but for licenced teachers it will most often be some combination of intuition, combined with formal activities that give rise to step by step decisions. They will therefore varies from teacher to teacher, and probably even from week to week.

The VaV approach provides a formal part for use within D. E.g, the concepts of TPS and SSs, with JLK, and RLK, PaS, and HOPs guide the teacher in creatively interactive design of SSs, and TPSs.

Note Probably, during the course of a semester, or a year, the creative teacher will select to design TPSs that come from each of these five value subsets of V - - and even other types of value subsets will occur to individual teachers as the "need/call" for them arises in the context of day-to-day teaching and decision making.

3.0 Illustration of the TPS Selection Process for the Given Design Task

The values for set V were selected according a combination of the criteria described in iii) and iv) above. We chose critical thinking skills, general education and big news as well as big mystery.

3.1 Decision Process Used During the Design Phase

We wanted to appeal to varied groups of students. So we selected a subset of V that has enough variety to interest at least in some parts of the TPS. (Sort of a "Something for everybody" philosophy, but filled with worthwhile and important material to be placed into the TPS). These were chosen because they are easily motivated and understandable. Also we chose to de-emphaize maths, because the VaV method is about PaS and HOP, so it leads students to go further if their interest is openned and motivated. And that is the purpose of creative teaching, to open and awaken interest in

a) questions about things around us, and
b) critical and analysis as an important part of good citizenship.

3.2 Restating the Goal of the TPS

First, we restated the given task as follows

a) The TPS should be interesting to diverse groups of secondary school students,
b) The TPS must explore, and attempt to answer, questions around the themes of
 b.1) "What is antimatter (AM), and

b.2) "What good is it to study AM ?

c) Since the distinction between M and AM is a classification scheme of some sort, discuss classification in some way (either as a direct SS, or as a PaS).

d) The TPS must use the SSs designed to meet the other requirements as PaSs that explore other topics and ideas not necessarily involving physics.

Note on Classification Lest the reader adheres to the requirement of c) above too strictly, we point out that in many classification schemes, some objects can be classified in different ways. The choice is usually made because it fits the needs of, or conveniences in, the context better than another way of classification.

Classification in the VaV Method In the VaV method sometimes it is hard to distinguish between SSs and PaSs, because the PaS itself is developed more, and becomes incorporated into the TPS as a "really good"SS. Sometimes the two appear very intimately mixed together. This has happened in the TPS described herein. Other times, the PaS is not developed because it seems to be very clear cut, routine, or obvious. So it stays a PaS. In other cases, a PaS remains a PaS because the object pointed to is too difficult for the level of the class, or because it is too controversial, etc.

4.0 Description of the Designed TPS

Recall that in the discussion below M = matter, and AM = antimatter.

4.1 Introductory Stepping Stones

SS1 To start the discussion of AM in a way that appeals to almost all students, we focus upon questions that have a semantic basis called forth by the use of the "anti" prefix. Very little physics JLK, or RLK is needed to ask the questions or to find them relevant and interesting. All that is needed is common sense and an ability to think through certain concepts.

The Questions for SS1

a) What is the meaning of the prefix "anti" in this usage? I.e., is it the same as, for example, in the word "anticommunist"? b) Could it be that AM=M? c) What is anti(antimatter), if anything?
d) What could A(AM) be? E.g., could A(AM) = M, (even if AM =/=M)?

d) If A(AM)=M, does it necessarily follow that AM=M? e) What is this concept of M, anyways?

Note: This last question is a PaS to a much more detailed discussion that is given in paragraph 4.2. I.e., this PaS is turned into several SSs and several PaSs.

SS2 Some students might be confused by the above questions and their following discussions. Here are two semantic games to give more understanding to some and to please the less scientific students too. Both of them generalize some aspect of the questions asked during SS1.

Game 1, Find examples of objects, Y, and modifiers, X, such that an object of type XY is not an object of type Y any longer. I.e., objects of type XY are not a subset of the objects of type Y.

Game 2, Using the same notation as in Game 1, the aim of this game is to find examples of X, and Y such that objects of type X(XY) are (respectively, "are not") a subset of objects of type Y. Consider two cases, when XY objects are a subset of Y objects and when they are not a subset. For extra credit answer the following: Is it possible to find X and Y so that XY=/=Y, X(XY) =/= Y, and X(XY) =/= XY? If it is, give an example.

These games, although based on the above questions seem important because they give the player experiences not only about real life, not only about words, but in regulations based upon classifications, and in simple analysis.

SS2.1 (and PaSs of Various Types) Examples for the Games

Example 1 For game 1 an example from daily life immediately comes to mind to any one who looks for possible inconsistencies or exceptions. I.e., "white chocolate" in not chocolate, as explained below. This example is important because it is an analogy to AM and M, and suggests that the question whether AM is M is a serious question for a beginner to consider.

By American and EU regulations, white chocolate is not chocolate, according to the legal requirements of food labelling laws. What makes the name appropriate (legitimate) is that white chocolate contains some chocolate ingredients, but not enough to meet the high standard required to be legally marketed under the various chocolate labels. (For more on this, refer to Appendix B, which also serves as a PaS to a fairly complex classification scheme for many types of chocolate, and that varies, in the details, from country to country).

Another case occurs when X = opposite, at least in the normal usage of the word. E.g., usually the opposite of something cannot be that something. For an exception note that in quantum mechanics, we can regard "particle nature" as the opposite of "wave nature", but light exhibits both natures - - though not at the same time.

Example 2 For game 2, the question, "Is A(AM) = M" is settled in the affirmative as follows. Since it is completely symmetrical whether particle U collides with particle Z or vice versa, symmetry applies to the collision process. Both cases are identical even though the point of view is different So whether we bring AM to M, or M to AM, the consequences are the same, and annihilation occurs. By symmetry, in an AM universe, M would be the anti of matter in that universe. So A(AM) =M, by symmetry. So AA= I, (where I is the identity operator) in the case of AM and M. But the question of whether AM=M, is not yet settled (see paragraph 4.2).

As a second instance for game 2, consider X to be the modifier, "opposite", and Y to be the south side of a street going from east to west. Then XY is the north side, and XY=/=Y, while X(XY) =Y.

Note This sort of thing (ie, AA=I) does not happen, in the case of white chocolate and chocolate. But we can go further with this example. I.e., initially one would think that white(white chocolate) is still white chocolate. But no, it is not! Actually, "white chocolate" has an ivory shade/colour due to the presence of chocolate fats. So white chocolate is not really white in colour. But something even more interesting is true. In some countries white chocolate is a regulated food label, and must contain a fixed (non-zero) percentage of chocolate fats. However, in other countries it is not a regulated food label. In some of those countries there are products marketed as "white chocolate", that are based entirely on non-chocolate fats. (See the web site referenced in Appendix B). In addition, they are really white in colour. I.e., in a real sense of the word, in the regulated counties, "white (white chocolate)" is neither chocolate, nor white chocolate!

SS3 More Questions Needing Little Physics, But Lots of Common Sense

These questions too need little physics prior knowledge, and need to be asked even if the answers are not possible without more work. Common sense is about all that is needed here.

After AM is defined in terms of annihilation whenever particles with equal masses and equal but opposite electrical charges meet, the following questions should come up even if just to direct further discussion, or to motivate interest for "more on this topic"

a) If AM and M always annihilate on contact, how close must they get for "contact" to occur?
b) Why is there any AM left if it always annihilates on contact with M?
c) Why is there so much more M than AM? Did this unbalance occur during the big bang, or afterwards, and how/why?
d) For that matter, if they were created in equal and paired-off quantities, why is there a universe at all?
e) How can we study AM when we cannot place it into a chamber made of M?
f) Can we use magnetic fields to trap charged AM particles, in a "magnetic" bottle?
g) Then what about trapping neutral AM particles, if any exist?
h) Does an AM particle have to have a charge or can there be antineautrons? Are there other sorts of M besides AM and Dark Matter?
i) How do these compare to the different phases of M?

PaSs of Various Types WEB search or Google for Matter/Antimatter asymmetry, magnetic bottles, Slowing down antimatter beams, creating antihydrogen atoms, etc.

SS4 Questions that Suggest PaS Directions at the Applications Level

a) How can we explain, Positron Emission Tomography (PET) to explain hospital uses of antimatter for diagnosis of patient conditions?
b) When a positron and electron collide, they have a certain total kinetic energy and momentum. Must this always be conserved so that after the annihilation, the gamma ray (or rays) preserve them?

PaSs of Various Types Websites for AM Applications

The website of the Positron Annihilation Community has some thing for every one from beginners to experts and researchers. http://www.positronannihilation.net/index.htm

One of many web sites for PET is at

the Wikipedia site, http://en.wikipedia.org/wiki/Positron_emission_tomography

SS5 Questions to Discuss and/or to Suggest PaS Directions at the Fundamental Level

These are more involved questions that have several follow up questions, and/or suggestions for experiments,

a) What causes the annihilations to take place?
b) Does annihilation also occur when, for example, a positron collides with a proton, or a antihydrogen atom with deuterium atom? E.g., in an antihydrogen/deuterium collision, would all be annihilated except a single neutron? If not why not? And then, can we say that positrons are AM only for electrons, but not the "anti" of protons, or any other matter except electrons? I.e., are positrons the AM of electrons only, but not of any other particle that does not contain electrons? (If that is true, then the prefix "anti" seems to be a misnomer, and there are many types of AM, depending on their electrical charge)

c) Is there some sort of natural law that says "Whenever two particles with equal mass, and equal but opposite electrical charges meet, then annihilation takes place?

PaS A Speculative Attempt to Explain Annihilation

In semiconductors when an electron moves from the valence band to the conduction band it leaves a "hole" in its place. Another electron can now move into that hole and create another neighbouring hole. Could it be that our universe is , say, the valence band, (in some vague way that has still to be defined and precised)? If so, then the antimatter particles would be holes left by particles of the universe that have moved into something equivalent to the conduction band in semiconductors? Unlikely, but worth an attempt. E.g., the vacuum energy could be a very fine "matter" (again, pure speculation) that acts as a "sort of" semiconductor to all the matter that we see without regard to charge, because it is not working on electrons that are bound to atoms, but on matter that is bound to a "subvacuum substrate of lattice points".

Note This PaS ties to the outmoded concept of ether, to semiconductors, and to speculation about how the energy of vacuum is not zero, causing spontaneous creation of particals. See paragraph 4.2.3 for further speculation that might tie into this speculation.

4.2 SS6, A PaS and SS combined: Looking Deeper into Matter

Elementary/ Classical Definition Matter is anything that occupies space and has mass.

While searching for a possible difference between M and AM, we study what is known about matter. The question about types of matter, as we have defined it, we see that any two different types of matter need to be different in the mass that they possess or in the space that they occupy.

4.2.1 The Types of Mass Possible

Three types of mass have been identified, (for more details see, Mass, Wikipedia site, http://en.wikipedia.org/wiki/Mass), which discusses them and their effects in greater detail).

a) The inertial mass of a body, is defined by Newton's second law of motion, F=ma, where F = force acting on the body, m = the inertial mass of the body, and a = the resulting acceleration of the body.

Note Many experiments have shown that AM appears to have the same inertial mass as matter. E.g., by the precise way in which charged AM particles respond to magnetic fields. So here we see that AM is M, at least partially, in the sense of having the same inertial mass as M.

b) The active gravitational mass of a body is the mass that causes the body to produce a gravitational field

c) The passive gravitational mass of a body is the mass that responds to a gravitational field.

Experiments have shown that for ordinary matter, all three of the masses are equal numerically, even though they are conceptually different.

PaS Google to find some answers to the following question. What sort of experiments have been performed to get the numerical equality, and what are the bounds of experimental error?

4.2.2 SS7, A Speculative Game about the Energy/Matter Connection

This is a game because it asks students speculative questions and encourages, speculative answers. The question of “reality or of accuracy” is not involved because that question can be asked at a later, more appropriate stage.

By Einstein’s famous equation E=MC2, (and many confirming experiments), we see that matter and energy are transferable. Energy has mass, and occupies space. So it seems to qualify as matter by the above definition.

Searching Questions. Why does this surprise some people? Because they remember their understanding of the above definition of mass, with the childish understanding that they had when they first met this definition in elementary school. I.e., they never seriously reconsidered the question of what is matter, or space with their mature physics understanding. I.e., we learn things as children, and unless they are reformulated, or rethought in later years, we have at least some subconscious concepts that need to be adjusted in order to fit in with a more mature understanding or with the progress, or new paradigm of scientific insight and perspective.

A “Natural” Question

Why is not energy regarded as a state or phase of matter? Is it just a ”matter of usage” or is there some real physical subtleness behind it?

Speculative Answer. There are several phases of matter: solids, liquids, gases, plasmas, condensates. They are changeable by changing temperature and pressure. Perhaps we should regard energy as a phase of matter too, because it too changes from one to the other?

Counterpoint The classical phases of matter can be easily reversed by temperature and pressure changes and can transfer back and forth between solids, liquids, gases. But going back from energy to matter is not unique. Irreversibility is not just “ a matter of” technology. How do we “capture” the energy of gamma rays or beta rays and transfer it back into the types of particals that they originally came from? Since these particles are emitted from various sorts of molecules, the reverse process cannot be unique unless the particles have properties that are way beyond anything envisioned by physics today.

Speculative Counter(counterpoint) Yes. That is true, but then energy could be a “phase” of matter in a yet-to-be-precised way, e.g., as a phase for subatomic particles, whereas the standard phases are between atoms and their relationships to each other.

PaS Google such topics as, phases of matter, phase diagrams, Fermi Condensates, Einstein-Bose condensates, etc. A promising paper appears at

http://jila.colorado.edu/~jin/publications/pdf/2005_770.pdf.

4.2.3 SS8, Is There a Type of Space that Is Unknown to Science?

Is there another space, different from the one that we see and feel with our senses, telescopes and microscopes, etc? In regard to the speculative attempt in the PaS for SS5, it seems that another space would be another property of matter that results in different types of matter. Both occupy space, but their spaces are different.

Speculative hypothesis: This could be a way to distinguish one type of matter from another. But for us to see it, it would have to enter into the space that we live in. Then it would, hypothetically, occupy both types of space, and be the AM that we see in experiments. When this AM particle that is partially in our space meets a particle of matter then the AM particle will serve as an entry for the M particle to enter into the useable space. And both will disappear. This too seems somehow related to a "far out" analogy with holes, valence bands, and conduction bands in semiconductors. At the moment this is all very hazy, unprecise, and not very hopeful. But many things start out that way, and it is important not to give up, as the next section shall show.

5.0 Three Stories Involving the Discovery of Antimatter

SS9 The first story is about the neglected minus sign when taking the square root of Einstein's energy equation and in Schrodinger's wave equation for an electron. Nobody conceived that negative energies could be meaningful and everybody "naturally" neglected them - - until Dirac considered them. This consideration lead Dirac to predict antimatter. The difficulty that he had to overcome is that systems tend to reach their minimum energies (such as a ball falling to the ground). So why do electrons with positive energies exist, when they can "fall" into the lower, negative energies postulated by Dirac from his consideration of the minus sign? Dirac postulated an infinite sea of negative energy states, and noticed that when totally full, it would not allow positive energy electrons to fall into negative states.

PaS Dirac got the Nobel prize (1933) for his work. We can say that Dirac got his Nobel for hard work in mathematics. But more illustratively and educationally, we note that much very fine hard work is not so rewarded. So we can say that Dirac got his Nobel for persistence with a "little neglected minus sign". I.e., he worked hard to reach the pinnacle of hard maths of the Schrodinger partial differential wave equation for electrons. But he went further. He questioned the neglected minus sign in the square root operation. He sought a way to overcome the paradox of negative energies. We can say, that Dirac got his Nobel for work on a minus sign!

PaS Google the Pauli exclusion principle (that excludes electrons from occupying the same state in any one atom).

SS10 The second story is about a set of experiments that Hess performed to explore the natural phenomena of what came to be known as cosmic radiation. Hess got his Nobel (1936) for taking balloon trips with a "hermeticly sealed vessel" to measure ionization intensities as a function of altitude. His data showed that the intensity of "some ionizing radiation" was increasing strongly at higher altitudes. This was very perplexing at the time (early 1910s) because people had no idea that the Earth is being bombarded with high energy radiation from outer space. Hess's highest reached altitude was five kilometers, in a balloon that he filled with helium, rather than the hot air coal gas that was usual at the time. The intensity of the mystery radiation increased with altitude once Earth-based radiation became a negligible contribution to the total intensity measured.

We can say that Hess got his Nobel for filling a balloon with lighter gas. By ascending higher and observing the continued rise of intensity, he concluded that the mystery rays were coming from above.

Well, to be more precise, in addition Hess did two other interesting things, also seemingly "minor" or elementary to us:

a) He naturally had to modify his instruments to withstand the much colder temperatures and lower pressures at five kilometer altitutes, and

b) He "proved" that the radiation was not coming from the Sun by noting that its intensity did not decrease during a solar eclipse.

PaSs of Various Types Google "Hess, Helium, balloon", etc.. One good site is http://nndb.com/people/731/000099434/. It also mentions how Hess persisted in getting his instruments to work at higher altitudes. Hess gave an easy short Nobel lecture that is worth reading. Cf., http://nobelprize.org/nobel_prizes/physics/laureates/1936/hess-lecture.html.

PaS However, it is important to note that it was Milliken, another Nobel laureate (1923), who finally convinced the scientific community that the rays come from above, by submerging the detection apparatus below a specified layer of water. The radiation decreased as he had predicted. He named the rays, cosmic rays because they came from the cosmos. This is an important SS, and an important PaS here: Millikan made a prediction, tested his hypothesis, and confirmed it. Hess "mearly" persisted in taking good valid data by improving his capabilities to extend experimental results further than others had done.

SS11 The third story is most interesting. Anderson, who was Milliken's doctoral student at Cal Tech got his Nobel (1936) for using a cloud chamber with a magnetic field around it to study the electrical properties of the cosmic rays at ground level. He gathered important experimental data on cosmic rays, proving that some of them were the AM predicted by Dirac.

In 1930, Anderson and Millikan, decided to follow up on the results of Skobelzyn, who experimented with tracks of cosmic rays in 1927, but did not persist as Anderson and Millikan did. In some of his data analysis Anderson extimated that some charged particles had an electron's mass but curved the other way in the magnetic field. He thought, "Aha! Antimatter as predicted by Dirac. But his thesis adviser, Nobel laureate Millikan, claimed that it was a "matter" of direction. I.e., he claimed the particles were electrons that had been reflected from the floor as secondary emission. (Hence the reversed curvature that Anderson was observing). In order to eliminate/confirm this possibility Anderson placed a lead board horizontally, above the photographic plate, into his cloud chamber. The radii of the curves (produced by the particals under the influence of the magnetic field) decreased dramatically because the (then still mysterious) particals were slowed down by the lead board. This proved that they came from above the chamber. In addition, he coined the name, "positron".

PaSs of Various Types Read Anderson's Nobel lecture, at http://nobelprize.org/nobel_prizes/physics/laureates/1936/anderson-lecture.pdf. Google the Right Hand Rule. Determine the radius of curvature followed by charged particals of velocity v in a magnetic field,B. Investigate cloud chambers. What is a Wilson cloud chamber? How was the magnetic field around the chamber oriented?

6.0 Conclusion

6.1 A Little Humor and Some Serious Comments about Persistance

Hess and Anderson shared their Nobel prize (1936) for their part in the quest for antimatter. Most interstingly, neither knew initially that they were on its trial. We can say that, like Dirac earlier, they got their Nobels for easy persistance Even though Hess eliminated the Sun as the source of cosmic rays, we can still say that Hess got his Nobel for filling his balloon with Helium to reach an altitude of five kilometers in the early 20th Century. Even though Anderson used a cloud chamber with a magnetic field to study cosmic rays, we can still say that he got his Nobel for placing a lead board in his cloud chamber to prove that positrons were coming from above rather than electrons coming from below.

PaS Being on the trail of something new, Anderson also used his experimental results to show that the positively charged particals were actually positrons and not protons coming from above the lead board. How would you go about doing experiments and calculations to convince the community that the mysterious particals were positrons?

6.2 A HoP and Motto

We provide a HoP through a motto, Persist. Persist. Persist. (Especially persist in simple attempts that might help us to understand some perplexities a little bit more fully). This is a worthwhile lesson for all students, in whatever they plan to do in life, but especially those with serious goals.

7.0 References

[1] Max Igor Bazovsky, Metóda vstup a výstup podla Pavla Mikulčeka pre výučbu fyziky, pp64-66, Conference Proceedings, Editors Dalibor Krupa, Marián Kireš, Festival Fysiky, Creative Physics Teacher June 22-25, 2008, Sponsored by SFS, Slovenská Fyzikálna Spoločnosť, Smolenice, SR

[2] Max Igor Bazovsky, A Theory for More Creative Teaching With the VaV Method, pp 94-102, Conference Proceedings, Editors Dalibor Krupa, Marián Kireš, Festival Fysiky,Creative Physics Teacher III, May 4-7, 2010, Sponsored by SFS, Slovenská Fyzikálna Spoločnosť, Smolenice, SR

APPENDIX A Guidelines for TMF (in English, IYPT)

This appendix reproduces some guidelines for the IYPT (TMF in Slovak). The full set can be found at the TMF website, http://www.tmfsr.sk/. It gives a structure that can be used by teachers to select what to stress and focus upon when selecting elements of the Value set,V. I.e., it is not only about physics. As the following quote shows, selecting the subset of V, and making the decisions of the TPS, and the SSs is also about self evaluation, asking questions, and grading one's own work as well as that of others.

The tournament is a set of battles between three teams, that have different functions. The Reporter presents a report about their solution to a problem. The Opponent opposes the reporter's work and strives to uncover weakness as well as the good points reported. The Reviewer evaluates the work of both the Reporter and the Opponent. The three teams rotate (with different problems) so that each performs as a Reporter, Opponent, and Reviewer. The battles are judged by juries that use the guidelines introduced below for their marking strategy. Following is a quote from the guidelines:-

„Jury Guidelines The grade for each of the three teams consists of a partial grade for "physics", a partial grade for "presentation" and a partial grade specific to the team's role (Reporter, Opponent, and Reviewer).

„A report worth 5 points would show that:

The Reporter has presented appropriate ***concepts, theories and principles*** for the problem. They have ***explained*** the processes of the phenomena and have ***applied appropriate mathematics***. The Reporter has selected a reasonable experimental technique to ***gather and record data*** (or demonstrate the phenomena if appropriate). The reporter has ***linked theoretical and experimental findings*** to draw suitable ***conclusions.*** The presentation helped make the meaning accessible.

„An opposition worth 5 points would show that:

The Opponent did ***challenge the Reporter's understanding*** of the presented ***concepts, theories and principles***. They did show an understanding of any ***appropriate mathematics*** presented. The Opponent did critique the experimental technique used and question the validity of the data. The presentation and discussion did highlight strengths and weaknesses in the report.

„A review worth 5 points would show that:

The Reviewer did ask questions to clarify the Reporter's and Opponent's understandings of the presented ***concepts, theories and principles.*** They did show an understanding of any ***appropriate mathematics*** presented. The presentation did highlight some strengths and weaknesses in the report and discussion.

Please select each partial grade from the given interval and write it in the corresponding box.

Consider the suggestions you find here if applicable – don't punish missing "accurate answers" if there are no questions, or not finding shortcomings if there are none."

Note: Further material in the guidelines discusses the recommended grades for specific standards of perfomance for specific tasks that are expected/desired of the TMF/IYPT competitors/warriors

APPENDIX B White Chocolate

Wikipedia site http://en.wikipedia.org/wiki/Types_of_chocolate, gives a classification of chocolate types for various countries, using a quantitative method that gives minimum or maximum percentages allowed for a certain type of chocolate to be identified with a specific name. A quote from Wikipedia, site.

http://en.wikipedia.org/wiki/White_chocolate describes white chocolate more thoroughly for our purposes. Here it is:

White Chocolate Composition and regulations

„Despite its moniker, white chocolate is, by definition, not chocolate as it does not contain cocoa solids, the primary nutritional constituent of chocolate liquor. During the manufacturing process, the dark-colored solids of the cocao bean are separated from its fatty content, but unlike conventional chocolates such as milk, semi-sweet, and dark chocolate, the cocoa solids are not later recombined. As a result, white chocolate does not contain the antioxidative properties or many characterizing ingredients of chocolate, such as thiamine, riboflavin, theobromine, phenylethylamine, and serotonin. [1] Often times, the cocoa butter is deodorized to remove its strong and undesirable taste that would negatively affect the flavor of the finished product.[2]Regulations also govern what may be marketed as "white chocolate": In the United States, since 2004, white chocolate must be (by weight) at least 20% cocoa butter, 14% total milk solids, and 3.5% milk fat, and no more than 55% sugar or other sweeteners.[3] Before this date, U.S. firms required temporary marketing permits to sell white chocolate. The European Union has adopted the same standards, except that there is no limit on sugar or sweeteners.[4] Although white chocolate is made the same way as milk chocolate and dark chocolate, it lacks cocoa paste, liquor or powder. Some preparations that may be confused with white chocolate (known as confectioner's coating, summer coating, or Almond bark) are made from inexpensive solid or hydrogenated vegetable and animal fats, and as such, are not at all derived from cocoa. These preparations may actually be white (in contrast to white chocolate's ivory shade[2]) and will lack cocoa butter's flavor."

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