

М.А.МИЛЛЕР

# РАЗМЫШЛЕНИЯ



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Лекция I

Автор - Миллер Михаил Адольфович, профессор, физик, посвятивший профессиональную часть жизни электродинамике, в основном макроэлектродинамике, или максвелловской электродинамике. Сейчас - главный научный сотрудник Института прикладной физики АН СССР, и частично - преподаватель Горьковского (ныне уже Нижегородского) Университета. С возрастом (год рождения 1924) у него проявилась естественная тяга к раздумьям общего свойства, наверное, даже превышающим его знания и возможности, но тем не менее, как ему думалось, имеющим некоторую самобытность, что и послужило внутренним оправданием «выпуска на люди» сих мыслей, праведных и не совсем. Толчком же к этому поступку послужили две приглашенные лекции, прочитанные в летних школах в июле-августе 1990 года почти на одну и ту же тему: о способах думанья физиков. Ну, конечно, в этом была изрядная доля претенциозности и самоуверенности: ведь невозможно сказать за всю физику, уж очень она стала переплетенной с многоликой сущностью познания мира вообще, и часто бывает так, что два физика из разных «подфизик» (то есть разных узких специализаций) отдалены друг от друга взаимонепониманием сильнее, чем от нефизиков (разумеется, не всех, но все-таки). Поэтому мысли такого охвата всегда в какой-то мере личны, эгоцентричны, - они собираются около собственного опыта, собственного дела, собственного способа понимания доступных собственному уму вещей и их природы. И даже если они приемлемо точны в ограниченном «круге чего-то», их неумеренное расширение за пределы «мест рождения» чревато недоразумениями - в прямом и переносном смысле этого слова.

Этими известными и пояснительными словами автору (а он умышленно избегает пока личных местоимений в первом лице) хотелось упредить упреки со стороны людей, настолько глубоко сведущих в науковедениях (науках о науках), что всякое посягательство из «глубинки» (почему-то у нас это слово стало синонимом «провинции») могло вызвать ревностное раздражение.

С обеими лекциями в принципе можно знакомиться независимо. Первая прочтена в американско-советском лагере в Татинце (вниз по Волге километрах в пятидесяти от Н.Новгорода) и причем на английском языке. Аудитория была весьма неоднородной - в ней насчитывалось более пяти «отрядов по интересам», и лектору было невозможно подстроиться под слушателей без потерь, еще и, разумеется, из-за несовершенства (мягко говоря) его английского языка. Однако ниже приводится именно английский текст, слегка отредактированный с учетом совершенных и замеченных «ляпов».

Вторая лекция была подготовлена для «наших», нижегородских школьников (лагерь в Зеленом Городе, около двадцати километров от Н.Новгорода посуху), она произнесена и написана по-русски - на **первом** (как говорят англичане), **материнском** (как говорят немцы и французы), или **родном** (как говорят русские) языке автора, и поэтому он позволил себе более свободное изъяснение, стремясь следовать доброму правилу соответствия содержания и формы, о чем, впрочем, чуть подробнее говорится в нужном месте. Обрывочность, незаконченность фрагментов, пересекаемость и раскиданность утверждений и намеков входили в замысел, а не являлись последствиями неусердия, торопливости или - что еще хуже - неуважения к слушателям (читателям). И все же письменная версия второй лекции не точно следует устной, ибо последняя скомковалась при исполнении жесткими временными пределами.

В конце несколько слов благодаренья. Автор вряд ли бы сподобился придать лекциям вид, приемлемый для прочтения (а не только для прослушивания), если бы не убедительные настояния его учителя и друга М.Л. Левина, а также пожелания П.М. Литвинова, который надеется (дай-то Бог ему удачи) использовать какие-нибудь «штучки-дрючки» в тех дальних странах, куда он направлен (выслан) нашей щедрой Державой с просветительскими (по-видимому) целями.

Но это еще не все: автор вряд ли бы довел текст этих лекций до печатного состояния, если бы не помощь двух приятных ему особ - Н.Б. Криваткиной и С.Д. Миллер.

Н.Новгород, осень 1990 - зима 1991



*Миллер Михаил Адольфович* родился в 1924 году на улице Старая Канава города Сормова Нижегородского края. Во время войны (1942) служил в рядах Красной Армии. Закончил радиофизический факультет Горьковского университета (1949). Некоторое время работал в Горьковском филиале Арзамаса-16, затем поступил в аспирантуру Горьковского университета к профессору М.Т. Греховой. Защитил кандидатскую диссертацию по поверхностным волнам (1953), затем докторскую диссертацию по взаимодействию заряженных частиц с высокочастотными полями (1960). В настоящее время работает главным научным сотрудником Института прикладной физики РАН и по совместительству профессором Нижегородского университета. Научные интересы: электродинамика, физика плазмы и науковедение. Любимая геометрическая фигура - тор.



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## PHYSICISTS. MODES OF THINKING HOW PHYSICISTS DO THINK ON PHYSICS

Lecture 1

(delivered at the Soviet-American camping school Tatinetz 10.07.90)

M.A. Miller

### Prewords

I am out of practice lecturing in English. Therefore I have written my text beforehand. I shall consult my notes. Such a mode of speaking I would call lecturing with «self-prompting». It is certainly true only if the text is composed by the author himself. Obviously, another mode would be referred to as impromptu speaking. (I would not dare to improve the English language by putting in it the international term exprompting).

The lecture is divided into sections. I call them units. And I would like to inform the listeners about the titles of these Units in advance. Thus,

- Unit 1. Introduction. Greetings and Apologies
- Unit 2. Domestic Theorems for Personal Use
- Unit 3. Look! Put in Order! Connect!
- Unit 4. Why I Like the Number Three
- Unit 5. Three Types of Thinking
- Unit 6. Please Choose Three Miracles
- Unit 7. The Main General Principle
- Unit 8. The Creation of the Universe
- Unit 9. Thanksgiving

Once upon a time one man of wisdom from England claimed: the brain is a wonderful organ, it starts working the moment you get up in the morning and does not stop until you get into the office... To verify this statement I start ...

### Unit 1. Introduction. Greetings and Apologies

In the beginning I should like to tell you that it is a hard pleasure for me to speak to such an unusual audience. I feel the difficulties of three types which will have to be overcome. At least three.

One is a language difficulty. I am a firm believer in the essential and sufficient role which any language (and the language of words especially!) plays in the process of

thinking. Therefore I distinguish not only English and Russian *speaking listeners* but English and Russian *thinking thinkers* too. The World of words (or the Space of words) is not identical to the World (the Space) of thoughts. Why so? Is it equally right for all developed languages? Or following the well-known advice (slightly adapted to the case), may be all languages are equal but some languages are more equal than the others? More suitable for thinking?

There exists a set of questions and I am unable to find answers in every case. I am not sure that all of these questions belong to the class of the so-called *answerable questions*. I can go on asking you: what do you think about bilingual children? or about artificial languages that are studied from early (initial) childhood? May these factors change the entire system of human thinking? And so on. That is the first problem I propose for investigation, the problem of high importance: the whole life can be dedicated to reveal this **Enigma of the Nature**.

The second difficulty is connected with the audience. I know nothing about your interests and your goals which have brought you to this place. I guess only that the audience is very nonuniform and that it will be impossible to satisfy everyone (including myself too!).

Once upon a time one man of wisdom from England used to say: Every reasonable man would be adapted to the world whereas the unreasonable one would be trying to adapt the world to himself. Under this instruction you must play the role of the world and I shall be trying to pretend to be both a reasonable and an unreasonable person simultaneously.

And, finally, the third reason for my troubles. I suspect that it is of greatest significance for our mutual intentions to understand each other. My lecture (or oral communication, or talk) has a very strange title «How Physicists Do Think on Physics». However, frankly speaking, I do not know how they do it. But sometimes ignorance can stimulate some kinds of aggressive activities. It seems to me that I am one of the so-called professed physicists (do not confuse or do not mix up with professional one!) and hence I am able to demonstrate (to show in action) the ways of thinking of physicists without thinking about thinking and so on ... Then you will be able to observe my attempts and draw good conclusions yourselves.

## Unit 2. Domestic Theorems for Personal Use

Very often under unpredicted circumstances I used to employ the theorems which I call the theorems for personal use or «domestic theorems». As a rule they need not be proved being not unprovable in principle and being not trivial each time. The first example serves the purpose to explain my point of view both on the claimed (declared) subject of lecture and on the ways of application of some types of domestic theorems. I like to conceal the lack of self-confidence by means of the following statement (assertion): **The best way to understand something is to lecture on the subject concerned**. Obviously such a theorem can be verified (checked) only by testing. It justifies my hopes to understand something about modes of thinking. By the way, this theorem is nothing but a variant of the well-known English saying: The proof of the pudding is in the eating. Therefore I shall refer to it as to «the theorem about pudding».

Once upon a time one monk of wisdom from medieval Europe proposed another «intelligent» theorem. Some people consider it as a fundamental principle of our approaches to the interpretation of the Nature. However, I prefer to treat it as a guide to action. I suppose that some of my listeners (or readers) have heard about it. This is the so-called «theorem about razor» (quite a domestic instrument, isn't it?!) or «the theorem about Occam's razor». And now listen attentively to the Latin sounding (phonation) of this universal Occam's theorem: *Non sunt multiplicando entia praeter necessitationem*. At those times Latin was the common scientific language for communication of scientists by correspondence. Although I am not sure that they used it as a language of thinking. The English translation expressed with high solemnity is: **Entities are not to be multiplied beyond necessity**. I repeat: it is sooner a recommendation than the absolute truth. And it

may be transformed into a model domestic command: **Simplify without losses!** In the Russian slang I am able to put it into more expressive words: **Упрощай, не упушая!**

Thus, the first theorem mentioned above made us act fearless, the second one taught us the best method of action. And the theorem to follow (the third one) will give us a piece of good advise about more adequate wording of the results of actions. Here it is: **Any result (conclusion, law, assertion, theorem, proposition, affirmation etc.) might be expressed in the form adequate to the richness of the content, neither over-colouring nor undercolouring the truth stated in it.** It declares the equilibrium between logic and feeling. Though I am not sure that my formulation of this theorem has satisfied by itself the condition demanded to be met by it. And furthermore, may be you will be able to invent several similar theorems for personal use which will give you help (or relief!) in your throes of investigation.

### Unit 3. Look! Put in Order! Connect!

It might appear that the introductory presentations have taken too much of our time. It is not quite right because I have been eating my pudding without notifying this. There exists a great number of scientific approaches to the problems appearing both *outside* and *inside* us. But, as a rule, they have two common starting points. In the beginning of an investigation every normal person (and it concerns almost all scientists with rare but prominent exceptions) must have a look around. It is the stage of observation. (**Look!**) The second intention of a normal person is to systematize the phenomena observed. (**Put in order!**) And, finally, the third step (as usual as possible) consists in finding the casual relationships between results of the observation and systematization (**Connect!**) or, in other words, in assigning the laws (or something else) to the Nature. Another point of view: the Nature prompts us the laws (or something else) and we must be studious pupils if we want to hear its voice.

When I was speaking about my difficulties of lecturing I followed these instructions: to observe! to classify! and to connect! ⇒ the audience! the difficulties! the ways of understanding something among everything! and vice versa ...

### Unit 4. Why I Like the Number Three

It is now high time for a lyrical digression from the main train of my meditations. Any well-composed speech (as well as some ways of thinking), I suppose, is characterized by unpredicted fragments inserted into it by unexpected excursus. In terms of mathematics the moving speech must be slightly unanalytical. I am sure, the following frank confession of mine will be quite unexpected to you: I like the number **three** more than the other ones! And I cannot explain strictly logically why I do it. Do you mind to ask yourselves what number you like! Perhaps, you like no numbers at all or you have never thought about your attitude to them.

I shall try to explain «my bias» towards the number **three**. Sometimes I like to amuse myself by inventing mathematical or physical games with unusual rules. Now I shall tell you about one of my favorite games which is of interest from the pedagogical viewpoint too. Let us choose a number, any arbitrary number. Then let us try to find out some property or some phenomenon in the Nature which can be associated with the number you have chosen. For instance, the number **one** is associated with God, with the Universe or with the single «internal I» (*ego*). The number **two** can be related to two signs of electric charge or to the male/female duality or to the left and right asymmetry ... The number **three** can resemble us the three-dimensional world we live in ... And so on ...

It is the modern generalization of the Hebraic mysterious teaching (doctrine) which is known as the Cabbala. Our speculations can be characterized as a kind of natural Cabbala. My new «domestic theorem» is the following: the winner of this game is the number **three** (if we take into account both the quantity and the quality of associa-

tions!). I believe that it is true. Try to disprove it or try to adopt my Faith. A good exercise to train your brains!

### Unit 5. Three Types of Thinking

It is impossible to survey all information about our ability to think as well as about the structure of human brain. I shall outline some points of «clinical observations» only. One can distinguish three modes of thinking. (Please, note! We have encountered the number **three** again!). One is the logical thinking. Some people qualify it as the *algebraic* (series, step-by-step) mode of thinking. For 90% of individuals (the right-handers) the left hemisphere of the human brain produces (or generates) such sorts of thoughts dominantly. The second form belongs to the class of imaginative (*geometrical* or parallel) thinking. The corresponding work is produced by the right hemisphere dominantly. And, finally, the third mode is the most mysterious thing: it is the intuitive thinking, slightly or fully chaotic (*unanalytic*), its «sources» being distributed over the entire brain but dominantly in the deep layers of cerebral tissues. The «clinical diagnostics» which I described above (in extremely primitive approximation!) should not be taken (interpreted) absolutely. To know everything is to know nothing. Nevertheless all these points are reasonable in general outlines.

Every intellectual process involves all three modes of thinking being represented in different ratios. Consequently, one distinguishes three types of thinkers, depending on the dominating mode of thinking which is always an inherited trait (almost without exceptions). I like to call these thinkers in my own way (manner): left-minded men (and women, of course), right-minded men and chaotic-minded men (thinkers by intuition, by subconsciousness). The last term is not so felicitous as the two foregoing ones. I do not know a good English equivalent for the Russian: шалавый, шибутной, интуитор, «наитик».

A series of questions may be proposed. Who is who? - that is the first question. Are you right-minded, left-minded or mixed-minded (in the sense of combined-minded, or in Latin - *ambidextrous* or double-right-handed)? And who is who in the History of Science, Culture, Politics, etc.? Whose efforts were of the most valuable contribution to the Civilization? It is an outstanding problem, some of its aspects are intelligible even to a non-specialist. My answer is: the right-minded thinkers made a more significant contribution but they would not have succeeded in it if there had not existed left-minded people! And the best of all are yet combined-minded thinkers with a slight predomination «right» over «left».

### UNIT 6. Please choose three miracles

We are going on praising the plentifulness of events, facts, effects associated with the number **three**. Now I want to draw you to take part in a new game. Please choose «three anything» - three events, three Great Men; three phenomena, three highest achievements of our Civilization ... which seem to be the most surprising for you. Three Miracles of the World from your viewpoint (opinion or impression). It is not only an entertainment but an instrument of investigation of your interaction with the World. The choice is dependent on such factors as age, character, temper, social status, standard of culture and education, etc.

My answer is the following:

1. The phenomenon of the utmost importance for me is the existence of thoughts. The process of thinking. The ability of a human being (and, partly, animal) to think, to produce thoughts ...

2. My second Miracle of the World is the existence of General Principles that govern all motions and processes in the Nature. It is wonderful, indeed, to reveal that there exist universal laws in the Nature and that they are true throughout the Universe. Frankly speaking, it must be confessed that in my heart of hearts I doubt it but my hesitations only add to the High Rating of the Miracle.

3. The subject of my third **shocking** astonishment is a combination of the two

foregoing ones. I am deeply surprised that human beings are able to understand the Principles of Organization of the Nature using their skill to think.

The last point is not so trivial as it might appear at first sight. A human being consists of particles and fields that are quite the same as all matter in the Nature, therefore the third property declares the ability to understand itself by itself, i.e. without involving in the process of understanding any other means from mysterious «outside».

These are my **three**. I would be happy if you supported my choice even if your own choice does not coincide with that of mine.

## Unit 7. The Main General Principle

We proceed eating our common pudding employing some other «domestic theorems» without overemphasizing them. Especially often we use «the theorem about razor» and cut all factors of minor importance (as it seems to us today! or as it seems to me just now under a strict time limit). Thus, I shall draw your attention only at the Second Miracle I have chosen above.

Let us try to think over the sense of this Miracle. If there exists a **General Principle of Organization of the World**, it can be revealed always and everywhere in observable and latent form. Then everyone is able to detect it easily if one is able to look! to put in order! and to connect! The best way to discover it is to consider some simplest models (simplify without losses!...). Dealing with physics one prefers to call them ideal models (systems).

Let us take a point particle and try to study its motion under the action of external force. I omit all details of theoretical investigations, brain-twisting and guess-work and go straight to the result (to the answer). Along any real track of an arbitrary real particle, the difference between the kinetic energy and the potential energy is always (always!) minimized (in general cases, optimized). Then a bright surmise is sure to appear in our minds: the Nature likes to save its energy resources. A similar picture is true in electromagnetism: the difference between magnetic and electric energy tends to be minimized in any possible process.

After fruitful meditation we will arrive at a wonderful discovery: any system can be characterized by a function of several parameters which is minimized (optimized) in the real motion or process. Scientists invented a very expressive name for this function in physics: **The Function of Action**. And the corresponding General Law is known as **the Principle of Least (minimized) Action (PLA)**. Is it only the first step that is always the hardest one? Or does it take all kinds to make this World? But nothing succeeds like the first success. If all elementary motions are governed by the PLA, then all combinations of those motions (which our «macrolife» consists of) must contain traces of such properties. Naturally, most macrosystems are too complicated: a great number of separate motions (including the motions of thoughts!) take part in it. And very often we are unable to recognize what function must be minimized (or optimized), being sure that it exists in principle. The Principle exists in principle! All our deeds and thoughts tend to be optimal in a definite (not always understandable!) sense. And we live and enjoy ourselves without meditating upon it, without being plunged in the thoughts about our deeds and thoughts. We are able to solve most problems of optimization automatically. We live in the World of Optimization, probably, we ourselves are the Product of Optimization.

Once upon a time one man of wisdom from Germany said: God does not know how to calculate (to integrate and so on) because he solves all problems empirically. And we are created in His own image, after His likeness. Therefore we know how to act empirically also involving all intuitive power based on the acquired (gained) experience as well as on genetic instructions (experience of the former generations) and, in the final analysis, on the PLA.

When we are packing a suitcase or when we are planning our life we are taking part in the process of optimization.

The most ancient case of optimization is the problem of loading Noah's Ark. The

first rescue expedition but not the last one, I fear. A quite modern problem - how to survive under unfavourable condition of limited resources of everything. About hundreds of solutions have been proposed and developed, one better than another, and at the same time, one worse than another. Do you want to examine yourself and to propose your own project: an empirical solution of an optimization problem. You will see that it is a very-very-difficult task even to state the problem, to find not only the aim but also the means of achieving it. My own solution is trivial: the optimal Noah's Ark is our Solar System. And we should not hurry to leave it for the other World.

## UNIT 8. Creation of the world

Now it is high time to get to the happy end. The organizers of the school told me that every school-day must resemble the corresponding Day of Creation described in the Holy Bible. Today is the Sixth Day. The Day when God created man in His own image. Are you able to repeat His work or do it better?

This will be my last proposition to you: make an attempt to create your own Universe. You are permitted to have at your disposal all that you want to have, all fruits of your imagination, even those which were forbidden in «the previous reality» (the real reality is more primitive than the virtual one!).

It is very interesting to know what you will begin with. What must one put in the Beginning? The Word, the Idea or the Action? Remember that according to «the classical variant of Creation, in the Beginning God created the Heaven and the Earth ... and darkness was upon the face of the deep ... and God said, let there be light and there was light. And God saw the light, that it was good: and God divided the light from the darkness.»

Do you think that this way of Creation was optimal? Maybe it would be more reasonable to start from a good universal Idea, and best of all, from the establishment of the Principle of Least Everything (PLE) and, in particular, of Least Action (PLA)? Imagine: In the Beginning God invented the Principle of Least Everything (PLE) and God saw it was good... And as a result of the application of this principle the darkness and the light were divided all by themselves ... and so on ...

## UNIT 9. Thanksgiving

Thank all the listeners (and readers) for understanding and good reaction. Especially I thank those schoolgirls and schoolboys who were not comprehending my words and/or my thoughts but in spite of that were trying to take in my speaking as a whole.

Once upon a time one man of wisdom from Poland remarked: It makes me laugh to look at two left-handers when they are shaking their right hands to greet each other. So it was funny for me to speak English to the Russian-speaking (and Russian-thinking) subgroup. I am sure this lecture would better be performed in Russian. And the quality of the performance (as I persuaded you in Unit 2) must be brought into correlation with the richness of the content. I hope that every linguistic subgroup will make up for the corresponding deficiency without my assistance. **Thanks!**

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