

CONCEPTION OF GENERAL ABILITY TO MAKE DISCOVERIES. JOYS OF CREATIVITY FOR EVERYBODY

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Abstract

We need to think about our creative experience and to exchange it however modest it could be. Many outward hindrances and mighty self-braking together with complex of imperfectness for making discoveries must be removed. Really everybody is a potential discoverer. This gives the fundamental satisfaction of maximal self-expression. Some simple algorithms for making discoveries will be given. Do you enjoy or are you irritated by others' scientific success? Harmony of physics and 'lyrics' provides the highest effectiveness of creation activity. Some psychological constituents of scientific work and education, criteria of quality of scientific results will be considered. Let our errors help our work. Competition in

creative collectives has also negative aspects. Let us switch on talents and cease to extinguish them.

Conception of general ability...

The talents must be forgiven to the gifted people.

A.N. Kolmogorov.

Epecially if ones position makes it easier to extinguish talents.

There is nothing as valuable as 6 millions tons of human brain matter on the Earth and in the whole Universe. Diamonds, gold, oil, etc., for which wars were made are infinite times less important. And why do we use this treasure so unwisely? Is it not evident that for our common wealth and happiness these brains must work most intensively and effectively? It can be reached only by saturating the global brain matter by information. This cleverest material must be busy by the most productive work: inventions and discoveries. For this everybody must have as high education as possible and free access to almost any book, journal, video-, audio-products, etc., particularly, through Internet, independently of the rate of personal income. The informative interaction will evidently result in a nonlinear growth of cleverness and effectiveness of the mankind through the social many-body amplification. But now only a negligible part of the mankind has a comparatively satisfactory level of information. If we really understand the priority of these advantageous for everybody and noble goals, they would be easy to achieve. Instead, we loose countless genuine material and spiritual riches.

I work at the International physics institute in Dubna as a theoretician. We have taken an active part in the improvement of quantum mechanics. It results in radical simplification of this "unintuitive" discipline according to the previous opinion of the Nobel laureate Gell-Mann. Particularly, we have unexpectedly found some kind of quantum ABC. You can read about this in our last book "Submissive Quantum Mechanics: new status of the theory in the inverse problem approach" (in pictures). We placed its versions, Russian and (still draft) English, in a free accessible form on my homepage in Internet (<http://thsun1.jinr.ru/~zakharev/>). It appears possible to build quantum systems with the desired spectral properties of elementary quantum 'bricks and building blocks' as in a 'children toy constructor set'. We have found a favourable support by inverse

problem classics B.Levitan, L.Faddeev, P.Sabatier and Nobel laureates V.Ginzburg, I.Frank, Glauber. And it was for us an important step to make the quantum knowledge significantly more accessible to people in the world. Our experience convinced us that science could be simple. One of my teachers Zeldovich has not finished the university and I thought that his simplicity of posing and solving problems is a result of shortages of his education (the illusion that complexity is characteristic of big scientists). There was a contrast of his clear mind with that of my first scientific chief (the nebula with sparkles). Later I have understood that simplicity and clearness are signs of the highest quality. Gradually our belief that everybody can do discoveries was strengthened. Here was significant the social attractiveness of equality ideal, elaborated by centuries-old wisdom of the mankind and inspired us by the most noble its minds. The beauty of the idea even in the form of simplified model increases the probability of its truth. Here was helpful the evidence of some great scientists, which achieved the highest results that the logic of their ideas was very simple and natural. Certainly you have heard the statement like that the discoverer must be born with special talent. Do not believe someones pretensions to be a genetic exception which are unattractive and not convincing. Here is evident only intention (conscious or not) to undeserved consolidating of the discoverer's prestige. It is far beyond the possibilities of the present genetics. With all its successes it cannot and will not long be possible to pretend for understanding such delicate nuances of processes in mind. Even the most famous scientists are not enough competent in this problem.

Many years ago there was published an impressive paper about investigation of the labor of 10 thousands of metal workers. It appeared that 5 additional years of simple school education result in some increase of their productivity. But what seemed strange at first sight was the five times (!) decrease of defects in their production. And this additional education gave five times acceleration in transition from processing of some detail to a new one. Is it not paradoxical that geography, mathematics, languages etc., seemingly having nothing to do with the essence of metal work appears so important? No, even simple intuition explains us that it is quite natural. Any job is made better with the help of more developed, more flexible, cleverer mind. And what's more, the efforts once spent for knowledge give

then a return during the whole life. It is also easy to believe that the same effect of education must cause five times less diplomatic errors, e.g., stupid wars. You know many striking examples of such mistakes during the last years in the world. So similar generalizations to almost any kind of human activity can be applied. Particularly, education makes people of different countries mutually more attractive creating cleverer world ecology.

There is a possibility of global education without exception of a significant part of population. I want to mention two outstanding examples. The first one is a great schoolteacher, genius V.F. SHATALOV who invented how to teach children so well that pupils of any weakest class begin immediately to learn with good marks under his guidance. He arrived at this by reducing courses to separate elementary 'bricks' each of which was accessible even for the weakest pupil. It can happen also with ordinary teachers that a bad pupil has once prepared some lesson very well. But an ordinary teacher can give him only a low mark if he knows that nothing before was studied satisfactorily and also nothing will be in the future. However, Shatalov gave an excellent mark always in such cases. For the bad pupil it is a great event. He gets enthusiasm to master the next 'brick' and so on, and so on incomparable with what the best pupils feel. Another principal moment of Shatalov's approach was that he checked everybody's competence in any such brick of knowledge without postponing the encouragement. This includes all pupils without exception into the pleasant fascinating enthusiasm to learning process. There was also a special care about preparation of bricks to make them easy to learn, understand and to check quickly by the teacher. This reminds me of the simplicity of the algorithm of the Nobel laureate Landau who showed the direct and easy way to the much higher level of the scientific knowledge. My first scientific chief suggested me to pass the examinations of Landau's famous theoretical minimum. But there was an artificially created public opinion that only a narrow circle of super-students is able to do it. It appears to be a fraud spread deliberately for more comfort of a limited number of students (not a rare phenomenon in our imperfect world). Really, on the contrary, these exams were much simpler than the standard ones at University. It was possible, still learning in the first years, to pass these examinations which were of much better quality than the standard

PhD exams. There was a clearly defined, strongly restricted Landau's program: practically no questions outside the given textbook, from which even many sections were excluded. This made the exam comparatively simple and a not too nervous procedure unlike rather indefinite exam requirements at the University. The result was much more reliable and it appeared so accessible to start the process of joining the famous scientific school.

Further, we will also discuss the analogy of possibility in learning progress with intensification of mankind's ability to make serious discoveries. But before we shall consider the importance of knowledge distribution without exceptions in the world's population. Let us introduce the notion of an 'atom of information exchange' (Fig.1a). This is the circle of direct informational connections of anybody with his/her information environment. Of these atoms are constructed different information complexes (Fig.1b,c,d). It is a widely spread opin-

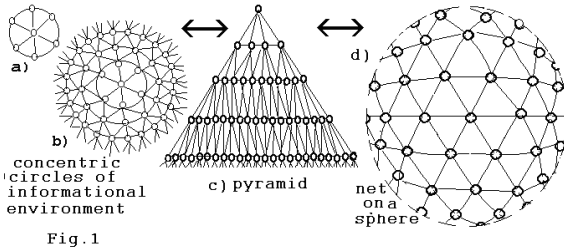


Figure 1:

ion that for some person with concentric circles of informers around him (Fig.1b) only the nearest neighbors are of crucial importance, and further circles are for them less and less valuable (seems natural?...). So people permit themselves to be uninterested in information quality of these far circles. But the presentation of the same structure as a pyramid (Fig.1c) reveals us clearly that if uninformed people substitute the ones at the bottom of the pyramid, the whole pyramid will go one step down in information quality. The same happens with the person on the top of the pyramid. So the importance of the last circle appears to be equal to the nearest one. We all are egoists and

want to be better informed. But there are different kinds of egoism from extremely narrow one to the world wide. So to say, egoism is characterized by the 'radius of its reasonability'. In the case when inside the circle of this radius there is only one person himself - it is most primitive egoism (less than Neanderthal's one), in the limiting case when all people are included in it - most clever egoism that coincides with the altruism. So the economy on education of poor nations turns out as global stupid self-confiscation of humanity wealth.

A praiseworthy step in the direction of noble deeds was the initiative of US National Institute of Health (NIH) directors. Nobel laureate Harold Varmus and later Elias Zerhouni have suggested an open access to the scientific publications. It is time for radical improvement of copy-right practice which now strongly restricts information exchange in the world. I have just found the Declaration on open access to knowledge (see <http://www.zim.mpg.de/openaccess-berlin/>; <http://www.eprints.org/berlin3/outcomes.html>; <http://www.zim.mpg.de/openaccess-golm/index.html>). US have also achieved one of the highest education levels (there is on average 'half-university education'). But it is important to overcome the national narrowness and spread this to the whole world and then even to make this level higher. In this case, there will be the full recoil of culture, productivity, and any wealth for humanity including US themselves.

I consider as a 'crime' of our scientific administration the establishment of 'age-apartheid' (artificial restrictions for older collaborators to take part in creative process). It would be desirable to include into creative activity everybody without exception, e.g., age restrictions. Recently I have found Fig.2 illustrating a 'paradoxical' phenomenon of not decreasing scientific productivity with age for active researchers. This is another basic element of optimism for a clever future organization of the humanity (see further for new such ideas). So the world will gradually transit from cave values: rough strength, sly adroitness, etc., to the genuine ones worthy of the information century. Inevitably we will combine all progressive achievements in the world's communication practice.

The creative activity makes people happy. We are convinced in possibility of the genuine democratic society when everybody will take part in this most interesting and productive being. It can be suited for any kind of work. We can consider this problem as for uni-

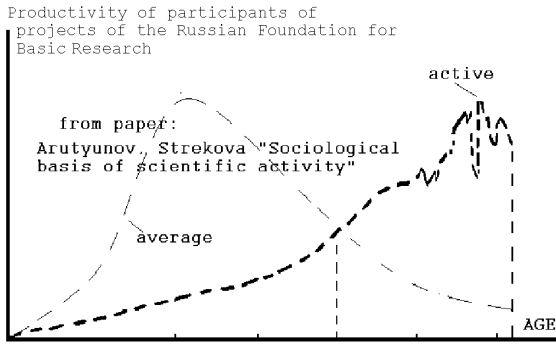


Fig. 2

Figure 2:

versal education to 'make discoveries of elementary bricks'. Recently I have tried to discuss my personal view on this delicate subject in our institute. It was not easy to dare to give such a seminar talk. Some of my colleagues recommended giving up this idea. They think that only opinions of great scientists can be interesting. Such 'modesty' is one of our disappointing mistakes (complex of defectiveness, suppressing our talents, self-braking). There must not be any restrictions (taboo) of themes for discussion, especially if it concerns our main business. And really any idea, which seems us important, must be transferred to other people. Here are some statements, which I consider important. When something is unclear, do not be ashamed of that you do not understand simple things you need for investigations. It does not mean yours unfitness for discoveries. Even simple things often require significant time to be mastered. We must not be afraid of asking simple questions. After accumulating necessary elementary constituents for your goal, it is useful to get accustomed to manipulate these simple bricks. And do not be ashamed if you are confused in several simple elements (again not to be embarrassed, do not think that you are a bad discoverer: even quietly and slowly we can go very far). All such difficulties do not mean that you will not find something that can wonder the world. As a rule real sci-

ence must be simple and clear. It usually consists of easy elementary, even trivial steps as the process of climbing of an alpinist a seemingly inaccessible vertical rock.

It is surer to move to the new science with reserve of your own original previous discoveries, which could be used in the new theories to be safer on the new unaccustomed territory.

Do not be the enemy of your own success due to the strong self-censorship and do not give way to malevolent outer critic. The complex of imperfectness of the majority of people is a natural reaction due to suppression of the individual initiative by the socially not enough developed environment. Even more, realization that some seemingly well known subject is not understood enough (at least by yourself) can be a significant step to discovery. Do not fear to doubt about some aspects of widely known famous classical results. It is useful to consider attentively whether there is something unclear in things even considered usually absolutely perfect. Probably you will improve their understanding even better than their authors. Determination of your lack of knowledge may be 'paradoxically' a start to your success. Analogously, it is promising to try solving paradoxes stimulating creative imagination. It is useful to search for contradictions in what is reputed totally understood. Encourage yourself, and do not be depressed by failures, which are convenient steps for future success. So we ourselves have found elementary 'quantum bricks' considering attentively visualizations of exactly solvable models of inverse problem (see our last book in <http://thsun1.jinr.ru/~zakharev/>). This in its turn allowed us to improve radically [Int. J. Mod. Phys. 18, 394, 2004] the classical Bloch theory of wave motion in periodical structures. Clear, simple and analytical formalism appeared to be like a 'black box'. You can choose some input parameters of the system, put them into PC program and get a result in pictures or a numerical form. But it is not enough to feel why the physical solutions of a free motion become destroyed by periodical perturbation on finite intervals of the energy axis. We used the acquired inverse problem intuition to find that the phenomenon can be explained by a new concept of resonance. It is the exact coincidence of fixed oscillation frequency of a potential with that of wave solutions in spite of continuous variation of total energy. We enjoyed this unexpected discovery. Do not forget: we are the main brakes of our inspiration.

Do accustom to praise yourself (self stimulations) for real achievements. It was very useful to relate new ideas to as many colleagues as possible: to 'strike sparkles of new ideas' from them. Here are important communications of the competing people without hindering one another. There is an illusion of rational opinion: that the appraisal of someone is considered as a direct damage for the authority of others ('swing principle'). I have not once told some collaborators the family names of most bright talents in our laboratory (according to my opinion) and the response was often negative. We often do not master the arithmetic of the genuine social values. So the community makes efforts for braking the common forward motion. Remember to the point the legend about the bird Bachrach having two unfriendly heads, which perished with pain because of poisoning one another (such a creative collective: self damage through the harm to another). Later Bachrach was revived by the highest forces as instructive example for others.

Lev Tolstoy once said " when I enter a school and see this crowd of ragged, retry, thin children with their bright eyes and often angelic expressions I am overcome by feelings of alarm, horror, as if I have seen the people sink. Ah, how to save and whom to save at first. And here is sunk the most valuable, just the spiritual that is striking in children. I want education for people only to save those sinking there Pushkins, Lobachevskys, Lomonosovs. And they teem in each school". Generally the history of world civilization, science, culture, literature is mainly the history of suppressing talents, no written masterpieces (chef-d'oeuvres), discoveries, extinguished stars. Only few persons (rare fluctuations of the masses of virtually possible) make their way to success.

For me it was revelation to find that we can adopt some aspects of experience of promotion of variety stars for activating talents in science, not for selected ones, but for masses (excluding artificial imposing the advertised artists). The practice of organizing multiple performances, etc., has a mighty stimulating influence of different audiences on the speeded up growth of skills. Clean, honest self-promoting, useful self-service, e.g., intensification of lecture activity, is also desirable.

Some details concerning these problems have been published in a paper "Do we need to extinguish talents. The model of ideal creative

collective"; it also can be found on my homepage in Internet. I believe that our fundamental interests are almost the same and do not contradict one another, which cardinally simplifies our many-body problem. It is advantageous to commend any success of others for better spiritual microclimate in our environment. Here it would be more justice to evaluate people according to their own previous capabilities (the maximal possible personal effectiveness of anybody is most profitable for the community). L.Tolstoy also wrote about one event in his life when the "praise made a mighty influence: due to the pleasant influence I became cleverer and ideas one after another with unusual quickness began to gather in his head". Do not forget that the moral investments are more effective at the bottom of the pyramid of the creative activity. The relative sensitivity is there greater. We are fantastically rich by reserves of moral encouragements of others, but rarely realize this our power.

In all our relations it is better to use experience of some clever tsar's ministers (I have read many their memoirs) who were able to convince the all-powerful monarch proceeding from his own interests. And so we can treat others as tsars and gain additional freedom by this (see the 'net on the sphere' model of 'prime ministers community'). Mutual hindrances in relations between scientists must be minimized and this must be generalized to the whole humanity. But it is useful to be less dependent on outer opinions about our work. Often it needed too much time to wait for high evaluation of our really good work. Even many Nobel laureates were discriminated by their administrations. Social literacy helps natural sciences as was affirmed by Nobel laureate Richard Ernst. He said that at scientific conferences special invited social reports or even social sessions would be appropriate.

In my scientific youth I understood that younger collaborators with less experience could stimulate us to solve problems which I had little hope to solve myself. Once I suggested to my much less experienced assistant such a problem, which, as I thought, was too difficult for me. Later I found that his believe in my competence strengthened my responsibility and persistence. That helped us to find the desired solution due to his confidence in success unexpected by me initially.

For me it was also important to understand that the practice of

transferring the unprestigious work to younger assistants for making myself freer was not a wise strategy. Their help becomes the more useful the higher is their qualifications. Really, the insufficiently qualified collaborators are as shells at the ship's bottom. They hinder the research. It is better to spend time making their qualification higher (without fear of competition from their side). There is profit of explaining your results to less qualified persons: after that you will better understand your own results and better, more clearly write papers, review articles, books.

Common algorithms help findings in physics and 'lyrics' (see some of them on my homepage <http://thsun1.jinr.ru/~zakharev/>). Particularly, we can use a physical percolation model to make clearer understanding of important social phenomena. There is an effect of 'optical illusion' that reveals the error of many aspects of our pessimism. Here the percolation model of some important, but hidden effects in social progress can be useful. The next Figure 3 shows the dependence of current $I(n)$ on the number of cuts n of the conductive net between different electric potentials. It appeared that random cuts of different connections between knots does not significantly change $I(n)$ from the beginning. But when at some big $n=N$ the net finally disintegrates into two parts, the current disappears abruptly. If a similar experiment is repeated, this happens almost at the same N value. An analogous effect is in the opposite direction. If we make connections between different initially unbound points of the net to be constructed, then $I(n)$ for a long time is zero and only near some big n there suddenly appears a continuous connection of two parts and the current jumps to approximately the initial value I in the previous experiment. This effect has much in common with the formation of public opinion. Pair discussions do not give for a long time any significant effect on the many-body community. So the majority of people think that it is not useful to correlate mutually individual opinions because it gives no visible effect. Really, we see that these pairing contacts are of fundamental importance. It is a necessary preparation for future public opinion. This is one of the elements of optimism: we can influence what happens with the society. There is another physical analogy: pairing correlations of electrons in metals can cause the superconductivity corresponding to the unified invincible opinion of the society. Something like this can help

us to overcome our impatience in scientific work while approaching a discovery by many simple steps. Once I asked myself how much

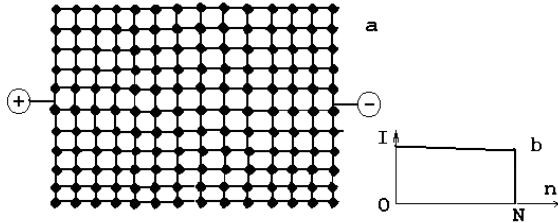


Fig. 3

Figure 3:

time I spend for thinking. And I was surprised that I, being a theoretician, think on my problems too little. Later I began to correct this unsatisfactory situation. For organization of the creative work the experience of the famous music composer Tchaikovsky may be instructive. He criticized another Russian composer Glinka who used to wait long for inspiration and produced little in comparison with his genius abilities. In contrast with him Tch. himself every morning began to work without ready ideas, but the inspiration came during the work. The Nobel laureate Pavlov also said "The essence of the scientific work is in the struggle with the unwillingness of work" (better instead of "unwillingness" to say "lack of skill to draw yourself into"). Something like this was also said by the mathematician Halmos in his memoirs: "I want to be a mathematician". He explained that although he likes his mathematics the most and it gives him maximal satisfaction, he often has difficulties with the beginning of his favorite work (feeling the internal resistance). In order to avoid tense thinking he began to sharpen pencils or to cut the nails. He finally understood that it is better to start by sitting quietly at the table with a clean sheet of paper and to write there, e.g., a simple question. Then gradually he drew himself into the serious work.

Soon after the beginning of my scientific work I had an instructive talk with Levitan, the classic of the quantum inverse problem.

I could not long dare meet him and ask many prepared questions. Finally I overcame the doubts and with fear made a telephone call to L. He invited me to his Chair in the Mathematical department of Moscow University. I expected either immediate answers to my trivial problems or reproaches in my incompetence. It was a great surprise that L. said after each of my questions that he himself did not know the answer. At first, I was somewhat frustrated. Later I understood that it was great. So L. confirmed the fact that I was at the boundary of what was still unknown. Any step further will be a discovery. So my questions were not at all absurd and I must be braver and search myself the solutions that were unknown for anybody. It is not so difficult because what humanity already knows is a droplet in comparison with the ocean of still not known.

Writing texts has much in common with making discoveries. It happens that I often feel very difficult to continue writing a paper (book). Sometimes you begin to hate the writing process. Why having ready ideas and expecting their immediate exposition in a written form it does not happen. It requires a long period to understand what was wrong in my practice. Do not think that you have not enough writing talents. Again it is hindered because many simple things have not been arranged in a proper way that needs some efforts. It can be due to our restricted memory: we do not remember the draft text well enough. And it is not so difficult to correct. I found that in my case it is because I still had not a clear enough notion of the whole manifold of my results. I must have a better notion of the multiple connections between the constituents of the future paper (book). Without strain we can read what was already written, but does not satisfy us. It is not difficult to transform separate sentences improving them without much trouble about still unclear notion what must be the whole work. Even this can be interesting if you believe this will finally bring you to the result whose quality will give you big satisfaction. Gradually going through the paper one, two more times we unexpectedly, but inevitably will find that now we have got the clearness of the whole thing. As in the process of discovery do not hurry to finish without fulfilling the first simple steps of polishing ('playing' with) separate phrases to accustom our memory disposing the draft of the elementary constituents. Do not be confused by the 'trivial' operations - the necessary infinitesimal movements to the final destination. So

we became able to make 'global' strategic reorganizations taking into account the whole text. It became a fascinating creative process and a much easier task. It could be so from the beginning if we believe that each simplest first step is a direct way to the desired goal. The love to the work is also necessary for readers pleasure. It is interesting that famous Landau said that he has no ability to write his own papers (books). Almost all of them were written by E.Lifshits. To emphasize the importance of the presentation form I suggest the following formula of effectiveness of scientific result: Effectiveness = (quality of the discovery) (how wide it is spread) (how accessible is its presentation). The value of the first factor increases the more wonderful, more surprising (difficult to foresee), but clear, universal and exact is the finding. Nevertheless, some of the scientists and our administrators are angry when others results and their presentations are bright. They seem to them "immodest". But really this paradox can be explained by their jealousy. It is more convenient for such administrators, guided by narrow interests of their 'commands' and not according to genuine scientific considerations, to determine themselves who is bright and deserves more encouragement. To defend their own perverted interests they can affirm that successful fundamental research is outside the frames of research plans (there were many examples of such discrimination even of future Nobel laureates). They try to force their self-narrowness upon the 'competing' colleagues. It is often done by less talented 'authorities'. At first sight it may seem logical: advantageous to fight against those who are not in your 'command'. This 'crime' results, e.g., in moral damage to the local community, which was not so immediately evident for socially under-developed physicists (lack of 'lyrics'). But really the scientific and spiritual losses appeared to be not comparable with the negligible gains. Higher moral promotes on average more beautiful ideas (see <http://thsun1.jinr.ru/~zakharev/>). Narrow group interests (injustice protections) are a less reliable basis for the scientific community. There also often are made errors in application value of scientific results. Just the concrete applications are most often of minimal value, comparatively not interesting (opinion of Hardy) and the main interest have new discovered wide connections of ideas.

The two last factors in the formula are very important because their neglect can make zero the whole effect. I was impressed by

the example of Jodrell Bank observatory where was organized special Visitor Centre for sharing outstanding scientific results among millions of Englishmen. My suggestion to follow somehow this experience in our institute, has not found support (maybe I was not enough persistent).

CONCLUSION

Our future must be better and better (at least up to some fluctuations). It will be much assisted by everybody's understanding of his/her own genuine benefits including (not perverted values), the fundamental need of creative self-expression. And this can be achieved without compulsion activation of masses for their own prosperity. Those who do not steel believe in better future are self punished by their social pessimism (mighty stimulus for improvement). And our efforts on the way to ideal goal of 'interpersonal soul' will be supported with the immediate prizes of perfection of our spiritual environment. For me there is an excellent example of Schweitzer, whose noble deeds for Africans provide him with the so great world's sympathy which no king could even dream.