THE TESTAMENT OF NIELS BOHR

Recollections

It is said that sooner or later every writer takes to writing memoirs. As for myself, being a writer of science-fiction I felt insured against this, when suddenly…

A photograph lies before me. It shows a group of writers, colleagues of mine in the profession. In the fore is the poet Semyon Kirsanov, in the back row are Leonid Sobolev, Georgi Tushkan and Boris Agapov. In front of me in the centre of the group is an elderly man and his wife. He has a tired face with a large mouth, high brow and keen, lively eyes.

This is Niels Bohr, a great physicist of our time, one of the founding fathers of modern physics, and one of the creators of the first atomic bomb. He had adventurously escaped from Nazi-occupied Denmark in a sailboat. He had founded the Copenhagen school of scientists, and any leading physicist of the first quarter of the twentieth century would have deemed it an honour to belong to it.

At his meeting with Soviet writers, Niels Bohr had spoken of the crisis developing in physics, a crisis resulting from the over-abundance of information. A situation had emerged similar to that at the close of the nineteenth century when, it seemed, all physical phenomena had been explained

and their laws expressed in terms of Newtonian mechanics and Maxwell`s electromagnetic field theory. All experiments corroborated the prevailing theories. All, that is, but one: Michelson`s experiment which, as is known, demonstrated that the velocity of light does not depend on the motion of the earth. There seemed no way of explaining the paradox, and some scholars would have preferred simply to shut their eyes to it. But then came a man with a "mad", as Bohr put it, idea: Einstein, who enunciated his relativity theory which overturned all previous physical notions.

At the time it was said that hardly six of Einstein`s contemporaries really understood him. Amongst them was Max Planck, who introduced the quantum concept. He was the first to support Einstein, comforting him with the words that "New theories are never accepted. They are either refuted or their opponents die out". To be sure, Einstein was not in the least worried whether his theory was accepted or not. He was so sure that he was right that he merely shrugged off complaints about the incomprehensibility of his ideas. And his ideas were truly "mad"-from the point of view of conservative minds, of course. Which is just why they have played such a great part in the advance of science.

On this note Niels Bohr concluded his speech.

«And that is why it is said,» some one of our group quipped, "that at a future All-Galactic Scientific Conference one of the esteemed savants will say, lifting a tentacle, «Earth? Oh, the planet where Einstein lived!»»

The anecdote was translated to Bohr, who smiled tolerantly.

«Professor,» my neighbour said, «today, when people have mastered the energy of the atomic nucleus....»

Bohr frowned.

«...when they have learned to explode atomic bombs…»

«This must surely be banned!» Niels Bohr inserted firmly.

... is the mechanism of nuclear decay clear? Did Einstein help in this?» the writer concluded his question.

«Einstein undoubtedly helped. In the previous century energy processes were conducted on the molecular level. Molecules joined in various chem-

ical compounds. Energy was evolved in the course of the reaction as, say, in burning. Atomic energy lies at a deeper level of penetration into matter. It is at this level that many of Einstein`s paradoxical principles were confirmed. However... a crisis of "too much knowledge» is again developing in science. Formerly everything seemed clear. The atom was made up of protons and neutrons in the nucleus and electrons in the shell.

The planetary model of the atom at first satisfied physicists. But then, as in the case of Michelsons experiment, information about the existence of unknown elementary particles began to invade physics. The behaviour of known particles could no longer be explained. For example, the electron displayed duality, behaving at the same time like a particle and a wave. To explain this it was necessary to introduce the concept of "uncertainty" and find a rigid mathematical interpretation of it. But more and more new particles are appearing which startle scientists by their unpredictable behaviour, short lifetime and unusual characteristics. Who knows how many more may appear?"

«Professor, perhaps elementary particles in turn consist of still smaller «bricks»?» some one asked. «What if the electron really is inexhaustible?»

«Knowledge is certainly inexhaustible, and knowledge of elementary particles is no exception. But to understand and explain what lies at the basis of the inexhaustibility requires new «mad ideas». Today the old ones seem self-evident. Though, of course, it is not a question of refuting the old ideas but of the old theories being true as special cases, as happened with relativity theory, which incorporated the classical Newtonian mechanics and Maxwellian electromagnetic field theory, which remain true at small velocities of motion incomparable with the speed of light.»

With my fellow-writers I saw Niels Bohr and his wife off, helped them into their coats, accompanied them to the waiting car. But all the time I was thinking of what he had said about "mad ideas." All of us present at that meeting took in his words as a kind of testament. They kept turning in my head on the way home. I tried to recall some "mad" physical idea.

That night I couldn`t fall asleep for a long time. When I finally did drop off I dreamed of the war and the fierce fighting I had witnessed on the Kerch Peninsula. And then I recalled it all...

My memory conjured up a short, stocky man, very soft-spoken and very polite, an artillery lieutenant by the name of Ilyin, as far as I could recall, and I shall continue to call him so.

We had met on the Kerch Peninsula in the tragic days of the German offensive.

I was the chief of a special group of the Central Engineers Department with an assignment to test in combat an invention made in cooperation with a friend of mine (today he is a member of the Academy of Sciences; I shall call him Osipov): a remote-controlled, self-propelled buggy for combatting enemy tanks.

Nowadays, of course, people control space vehicles (one of them created under the leadership of Academician Osipov) from the ground, but at the time our unsophisticated wire-controlled little buggy could prove extremely useful in battle.

Besides several of these buggies my group also had a light tank with a power plant to feed their motors.

On orders of the division commander, the buggies were hidden and carefully camouflaged. The armoured power plant took up a position behind a hillock, wires shaking from it to the concealed buggies.

My assistants, Engineer Katkov and Technician-Lieutenant Pechnikov, were to steer the buggies from shelters.

Ilyin`s anti-tank battery was positioned nearby, and I shared his quarters for the night with him. After a snack in a dug-out dimly lit up with a makeshift oil lamp fashioned out of a used cartridge case we fell to talking. And a most interesting conversation it was.

«You know, Comrade Military Engineer, » Ilyin began, «I simply can`t stop thinking of my physical problems. »

«Mm, yes,» I said, «but today there are other problems.»

«But the same laws of nature. Which must be understood and explained.»

I looked curiously at the lieutenant who chose to reflect on the laws of nature on the eve of battle.

«Of course, you`re an engineer, not a physicist,» he said half-questioningly, looking at me.

I said that I headed, together with Osipov, a scientific research institute, that we collaborated with Academician Ioffe and that therefore I was not altogether alien to physics.

«Then I`ll tell you,» he decided. «Who knows what may happen to me even tonight. Whether I`ll ever be able to publish my discovery...

«Your discovery?»

«Well, perhaps it`s too early to call it that. It`s not so much a discovery as a model of an elementary particle one could visualize.»

«You mean a model not only of the atom but of the particles that constitute it?»

«That`s right. You`ve grasped my idea at once.»

The lieutenant warmed to the subject. The flickering light lit up a part of his face and one moustache. He spoke in a soft, even, patient voice.

«You mentioned the model of the atom,» he began. «In the nineteenth century the atom was thought to be indivisible. In fact the ancient Greek word "?atom" means "indivisible". Our twentieth century has seen the structure of the atom revealed.»

The lieutenant went on to speak of Niels Bohr and his planetary model of the atom in which the electrons revolve around a central nucleus.

«But science can`t stop at, say, the electron as the ultimate stage of knowledge.»

«Naturally. Lenin said as much.»

«Everything was clear. There were protons and electrons, and neutrons were found. But then unwanted particles quite superfluous for the atomic model began to appear. There are already six of them. What is one to do with them? They differ from protons and electrons in their instability,

their short lifetime. The physicist Dirac predicted and then experimentally produced positively charged electrons-positrons. On contact the electron and positron vanished-annihilated, evolving energy according to Einstein`s formula: $E=mC^2$.»

«Can matter vanish?»

«Of course not!» the lieutenant exclaimed. «It would run contrary to the materialistic concept of the world. It is a question of internal structural change, not of the disappearance of matter.»

«What remains in place of the annihilated particles?»

«For this, one must visualize a model of a microparticle. I see it as two circular orbits on which certain material carriers of electric charges move. On one orbit they are all positive, on the other, all negative.»

While he spoke the lieutenant took a gun-shell band out of his pocket, then removed an old-fashioned wedding ring from off his finger and laid it inside the shell band. Then he pinched some bread crumbs left from the meal and rolled them into several white and brown pellets. He spaced the white pellets evenly on the larger ring and the brown ones (one less) on the inner one.

«Imagine these are the carriers of electric charges,» he said with a smile, pointing at the pellets. «They revolve at speeds approaching that of light. According to all the laws of nature they must radiate energy.»

«But elementary particles don`t radiate,» I remarked cautiously.

«Of course,» the lieutenant acquiesced. «But why? Because, evidently, the outer and inner electrical charges are rotating in the same direction but at different velocities and completely compensate each other. The radiation waves of each such system superimpose in such a way that the hump of one exactly coincides with the indent of the other. The result is no radiation.»

«But this would require an extremely precise coincidence of the number of charges and velocities of rotation.»

«Precisely,» the lieutenant said delightedly. «One can calculate very exactly and determine the states in which microparticles can exist»

«Interesting.»

«Obviously, all natural structures survive only in their stable states. There is a limited number of such states. They can be arranged in rows just as in the Mendeleyev table.»

«A table of elementary particles, in other words?»

«Not quite. A periodic system to be more exact. Each row contains the most suitable and stable state of a microparticle, a state in which it can most likely exist even separately from other particles. This is impossible in its other states, which are unstable. In the first row of such a stable system is the proton.»

«But other particles can occur in the row as well?»

«Not particles, but states of the same particle. That`s the rub! The whole thing is that there is only one particle which occurs in different states, and in certain conditions it can jump from one state to another.»

«How can a jump occur between one nonradiating state and another? Shouldn`t radiation take place between the states?»

«It`s a treat to talk with you, Comrade Military Engineer. Evidently in certain conditions carriers of electric charges coalesce into a ring on the orbit. And as is known, circular electric current does not radiate. In this state a microparticle can change its size without loss of energy, it can even split and in the new form turn into a state when as it were material knots appear again on the orbit as carriers of electric charges.»

«How can you prove this to be so?»

«This model makes it possible to compute the characteristics of a microparticle, its mass, electrical charge, magnetic moment, the moment of momentum due to the rotation of the charge carriers. All this can be compared with experimental data.»

«And?»

«They coincide completely!»

«Mm-yes,» I could only drawl, stunned by all I had heard. «And it`s such a simple scheme.» I pointed at the rings and bread pellets.

«It couldn`t be otherwise,» my interlocutor said with his soft smile. «Complex things are made up of simple ones. Incidentally, the pellets, that

is, the electric charges, can be imagined in mirror reflection. Then we have an antiparticle: an antiproton instead of a proton, a positron instead of an electron. Perhaps the time will come when people will learn to release energy by the coupling of such mirror particles.»

At the time of our conversation few people had considered the possible uses of nuclear energy, but he looked far ahead.

«One can imagine the universe,» he went on, «as a vacuum filled with a material substance.»

«They used to call it the ether before. A kind of matter without mass.»

«Exactly. Vacuum, which apparently contains nothing, is in fact quite material. Therefore it is natural to speak of its mechanical properties: of the complete absence of density and at the same time the elasticity of a "?supersolid body". »

«You know, Lieutenant, I`m struck not so much by the logic of the picture you have drawn as by the agreement of your theory with experience. Why don`t the physicists know of it?»

«I hadn`t had time to tell anyone of my ideas, I haven`t spoken of the results.» He looked at me again with a smile, then back at the table on which he had written rows of figures. «As a matter of fact, I`m continuing to work on my theory here at the front.»

I glanced with surprise at the stocky, soft-spoken lieutenant. He hardly resembled an Einstein, but all he said seemed no less significant than even the relativity theory.

«And what about Einstein?» I asked.

«There`s complete agreement with him too,» the lieutenant said. «His relativity theory will be a component part of the more general theory, which I would like to evolve on the basis of Einstein`s own unified field dream. The field actually is unified in its different manifestations: magnetic, electric, inertial, and even gravitational. It all develops from this model.» The lieutenant tapped the two rings with the bread pellets. «But even this future theory will eventually become merely a part of an even more general theory of vacuum.»

I looked at the lieutenant`s excited face, then back at his ingenuous «visual aid.»

At that moment an orderly, a mere boy with round eyes and a forage cap perched low over them, rushed in: The Germans had launched a panzer attack.

For some reason I thought of Archimedes who had been drawing circles in sand when enemy soldiers took his native city. A Roman refusing to wait until the «madman» completed his calculations, killed him.

The lieutenant and I rushed to our respective positions.

From my observation post I could see only the hillock behind which Lieutenant Ilyin`s battery had taken up positions.

The Kerch Peninsula is barren, hummocky steppeland. From the top of the hillock I could see oil tanks on the outskirts of Feodosia. Not a tree, not a bush in sight. The soldiers dug into the ground, making use of every fold of the terrain.

The German panzers crawled menacingly down the sloping mound.

Ilyin`s battery opened fire. The front tank stopped, black smoke billowed out of it and crept along the ground.

The other panzers, spotting the battery, bore down on it, their own guns spitting fire.

Another tank went up in flames, and one more came to a halt, its tracks damaged. I didn`t know what was going on at Ilyin`s positions, but I saw two enemy panzers crawling over the hillock to them. They would grind the battery under their tracks! Would my physicist survive?

But now one of our buggies crawled out of its shelter and headed straight up the slope towards the foremost tank.

The men in the tank spotted it, probably not realizing what it was.

They fired a burst at it, just in case, and a bullet evidently short-circuited one of the electric motors. The other continued to work and the buggy wheeled in a wide ark, circling the tank.

Another buggy rolled out, steered by Pechnikov. The tank was too close to dodge it. A plume of flame and smoke erupted with a roar. When the smoke dispersed we saw a jagged hole in the tank`s armour.

In spite of their losses the German panzers continued to attack Ilyin`s positions.

Perhaps the blast of our buggy roused the artillerymen, and they renewed their fire: Another tank caught fire.

The others wheeled aside, made an attempt to get through at another sector, but also encountered anti-tank fire. After that they turned back.

A lull ensued.

Worried about Ilyin, I made my way along trenches from my observation post to the anti-tank battery. My alarm was proved to be wellfounded. Only one gun of the battery remained intact. The artillerymen had rolled it out of its shelter for direct fire. The lieutenant wasn`t among them.

I approached another gun, damaged by a shell. A girl medical orderly was kneeling at a carriage wheel. Her bag with the red cross on it lay open on the grass.

And there was my physicist-lieutenant, lying next to two killed men.

But he was alive, laid out on a stretcher to be carried to the medical battalion.

I looked into the wounded man`s eyes. He looked back at me and tried to say something, but his lips only twitched soundlessly.

The lieutenant was carried away, the dead were removed. Two more guns were rolled up next to the intact one and another lieutenant, tall and thin and very young, took command. He rubbed his chin nervously as he tried to speak in a stern voice.

At that moment we received an order to retreat.

I hurried to the dug-out where I had spent the night.

Hardly stopping to think what I was doing, I stooped over the rough-hewn table and, lighting an electric torch, jotted down the numbers the lieutenant had written down. Seeing the shell band with the dried pellets of bread I mechanically shoved it in my pocket.

Later I forgot all about it.

We retreated to the very Kerch Strait. The remaining buggies and our armoured power plant had to be blown up....

Our crossing of the strait was a bitter experience, but it is not the subject of my narrative. Several motor boats left the shore before I boarded one, but a German aeroplane sank it. Together with my comrades I had to reach the Taman coast swimming.

It was like a different world: no sound of shell-bursts, moans or cries... cicadas chirped, lazy waves lapped softly the shingle beach. A bright sun was shining, but my teeth chattered.

Following the example of my companions, I stripped and laid out my uniform to dry.

It was strange to be on a beech sunning ourselves and knowing of the inferno on the other side of the strait.

As I stretched my tunic on some stones I discovered the shell band with the wet pellets of bread. I reached for my pants and found the wet notebook into which I had copied the figures in the dug-out.

I didn`t know whether the hospitals had managed to cross the strait or whether the lieutenant had survived.

When, towards the end of the war, I was at the front again and was entering Vienna with the advance units, the fighting on the Kerch Peninsula seemed a vague dream.

Then later, after the meeting with Niels Bohr, I really did dream of it-in connection with the physicist-lieutenant`s «mad» idea.

I know several physicists.

Now, at that late date, I finally decided to recount all I had heard that night in the dug-out.

They listened to me with polite smiles and went on to explain that the ideas concerning the structure of microparticles put forward by the unknown lieutenant an hour before the battle were but a crude vulgarization. Modern authorities leave no place for «visual models» of elementary particles. They

are necessary only to people ignorant of mathematics which can give an excellent expression to all phenomena of the microworld.

Feeling rather foolish, I took my leave.

In October 1967, I received a telephone call from Professor L. A. Druzhkin, president of the Physics Department of the Moscow Society of Natural Scientists

«I know you`re more of a physicist than you give yourself credit», he said, inviting me to attend a meeting of the department.

The topic of the report was a new theory of elementary particles. I was not surprised as nowadays many attempts are being made to form a picture of the bricks of the universe. One need but recall the mysterious quarks.

The speaker seemed familiar. Time had left its imprint on him as well as on me. He was nearing fifty, I had passed sixty. But when he started speaking I recognized him at once. The same soft voice, the same attentive politeness towards every listener, carefully chosen words and extreme modesty.

But how his theory had changed and developed! No, he hadn`t been marking time these twenty-five years!

The Moscow Society of Natural Scientists is an extremely authoritative body and leading Russian scholars have been reporting their discoveries to it since 1805.

My old army acquaintance was listened to with great attention by professors and doctors of science, to say nothing of enthusiastic young people.

It may be that the main thing in every theoretical work is its correspondence to experience.

The physicists sitting with me in the room could see how remarkably the speaker`s theoretical calculations agreed with the results of the latest experiments. All the known elementary particles had a place in the periodic system of microparticles and their characteristics coincided to the fifth decimal figure and beyond in all cases where experimental data were available. And where they weren`t? This is where the physicists were in for their greatest surprise. The periodic table predicted the existence of a great num-

ber of as yet undiscovered particles. The audience were shown a catalogue of microparticles whose characteristics had been calculated by computers in Leningrad according to the formulas of the author of the theory.

All these twenty-five years, it turned out, Ilyin had been in no hurry to make public his work, which would no doubt revolutionize many physical notions. Naturally, all he was now saying was a far cry from our night-time discussion in the dug-out. Now it was a «correct,» mathematically substantiated theory.

That, at least, was how it was described by one of the first to speak after the report, Professor Protodyakonov, Doctor of Physico-Mathematicai Sciences, a leading figure at the Institute of Terrestrial Physics of the U.S.S.R. Academy of Sciences.

One after another the physicists took the floor, and not one of them opposed the theory, first heard by me twenty-five years ago.

However, as it turned out, I wasn`t the only one who had got to know it then.

Towards the end of the meeting Professor Druzhkin remarked that he had been following the theory`s development for more than twenty years.

The Moscow Society of Natural Scientists passed a decision to have the new theory of microparticles published.

I recall that an editor of the Mysl Publishing House sitting next to me, who didn`t know of my long-ago meeting with the speaker, whispered:

«You know, he looks a little like the young Einstein.»

Of course, he no longer looked like the young man. I had known him young, after all!... But there was something in him that did make it possible for the editor to note the resemblance.

My acquaintance with Ilyin was renewed and we frequently met and spoke together.

I realized how hard it would be for him to convince the sceptics and refute his opponents.

Under the impression of my renewed acquaintance, I sought out my old friend with whom I had once worked on the anti-tank buggies, Academician Osipov.

For twenty-five years we had each followed his own road. I wrote books while he… Suffice it to say that today he is a Hero of Socialist Labour, a Lenin Prize winner and an Academy member... In short, busting, energetic, mobile and restless, with a shock of grizzled hair, huge brow and Mephistophelian profile, he could well have been a hero of one of my science-fiction books.

I knew my old friend had once dreamed of bringing together all fields: magnetic, gravitational, inertial. He had approached the problem as an electrical engineer who had designed quite a few machines in his lifetime.

I told him of the new theory of microparticles.

«Listen,» he said, «you`re a writer of science-fiction, and you should be able to imagine what follows from whatever you hear.»

«Very well,» I said. «What if I describe how you showed interest in the theory and decided to apply it in real life?»

«Go ahead, Sasha. I promise that if you make it sound convincing I`ll plunge into the fight together with your lieutenant.»

That is how a fantastic idea has entered this realistic narrative. I received the right to imagine my academician plunging into a fight for...

Dreams

What could a man like him plunge into battle for? For theoretical notions? No, he is not of that bent. He has created working machines which have made a revolution in technology.

So, first of all, my academician must meet my army friend.

And they met.

The academician`s office, where he performed his duties of institute director, was situated in an old mansion with stained-glass windows. Here he discussed problems with theoreticians or raked errant shop or laboratory superintendants over the coals.

Now he was pacing the room in an apparent state of excitement.

«Do you realize what you have accomplished?» he asked sternly, halting in front of his visitor. «You yourself don`t understand what you have invented! Little beads? With minute electric charges on them? Do you see that chandelier hanging from the ceiling? It has six bulbs on the outer ring and five on the inner. During the war the inner bulbs were blue. Charges of opposite sign. Do you see? A model of your microparticle. Now, let us break the chandelier».

«What do you mean?» the theoretician asked in surprise.

«This. In the nineteenth century people had a knowledge only of electrical processes taking place on the molecular level. In our age scientists have penetrated the atomic nucleus and extract energy, not from chemical, but from nuclear bonds».

«Of course.»

«How are your rings bonded?»

«I have it all worked out. The proton binding energy, for example, is fifty-six million times greater than its annihilation energy.»

«Precisely. And this is our starting point. What kind of energy is it?»

«The inner binding energy of the particle».

«You can`t make yourself say it. It`s neither chemical nor atomic energy, it`s vacuum energy».

«You are probably right».

«Thus we can imagine a microparticle arranged like that chandelier and find a way to split it and utilise the liberated energy. This is already for the man! Have you ever thought of that?»

«I didn`t care to think of it. I had set myself the sole task of formulating an ordered theory which would be in agreement with experimental data.»

«With me you must go farther! Attack the microparticle. When people realized the magnitude of nuclear binding energy and proceeded to liberate it they ushered in a new, atomic age. So now.... You understand?»

The visitor was dazed by the torrent of ideas engulfing him. He seemed to have set off a flood which was to sweep away former notions, and now it had escaped his control and the theoretician felt himself carried off by the current.

«There is a large number of fine engineers working in our institute`s departments. We`ll give them the task of breaking down the microstructure. With what? Why, with what comprises it. Does it possess magnetic moment? It does. You have computed it yourself. Suppose we hit out at this little magnet with a magnetic field of incredible force?»

«We could probably find a way of acting on the microstructure.»

«Theoretically. But there is a wide gulf between theory and practice. We shall bridge it. You know, of course, that Academician Kapitsa, when he was working with Rutherford, built an instantaneous action electric generator. It had a massive fly-wheel which was revolved to a high speed then stopped quickly, using the generator as a brake. The instantaneous power was tremendous and the magnetic fields were of unusual strength.

Later Sasha - the writer whom you met at the front and who later introduced us - and I tried to make such electric guns. He even wrote a novel about it, Flaming Island. Storage batteries of tremendous power are required, super batteries.»

«Yes, I`ve read all about it.»

«Let us return to what you`ve read on a new level. Technology develops in spirals. Today metal is forged by means of magnetic explosions. Have you heard of it?»

«No.»

«More`s the pity. It`s most ingenious. When Sasha and I were busy with our magnetic guns we needed powerful capacitors. Today we have lasers, and for them powerful capacitors have been developed. Time was when in this very room Abram Fyodorovich Ioffe and I discussed how such capacitors could be made. And we made them. Now they are mass produced.»

«Are there enough such capacitors or machines for the purpose you have spoken of?»

«Of course not! We`ll get our engineers together and set them a really "mad" task, as Niels Bohr would have said: let them build an electric machine capable, even at the cost of vapourizing itself, of creating, for a millionth of a second, and if only at a single point in space, a magnetic field of incredible magnitude, greater than those existing in microparticles. This field will crack our "microchandelier".»

The visitor left in a daze. He had expected criticism or support of his theoretical ideas, but not the flight of imagination he had just witnessed.

Academician Osipov proved himself to be a man of action. He required neither reminders nor advice.

The years slip by unnoticed so that when you enter the same long office with the fireplace you can hardly say at once how many have actually passed.

This time Ilyin and I came together.

«We`re flying to Feodosia,» Osipov announced without stopping to inquire whether we agreed or not.

«Why to Feodosia?» I asked in surprise.

«We need the Kerch Peninsula. The very spot where we had launched our buggies against the fascist panzers. We`ll be carrying out magnetic explosions there to break "chandeliers".»

I couldn`t grasp at what point chandeliers came in, but my companion did and got very excited.

Again, as in those distant wartime days, the steppe of the Kerch Peninsula lay before me. It was a clear spring day and the ground was covered with blossoming tulips scattered amidst lush grass: delicate, varicoloured but odourless little waxen cups with dew-drops clinging to their sides.

Academician Osipov loves wild flowers, and now he seemed to have forgotten the purpose of our visit and began to pick them until he had a huge bunch of tulips in his arms. We helped him, but he was insatiable. That was him all around: always insatiable.

I stood on the top of a mound, drinking in the sight of colourful waves spreading out over the steppe.

What looked like chalk cliffs could be seen far away through a purple haze. It was the tall buildings of Feodosia. Perhaps it was from this very spot that I had once looked at the oil tanks in the distance.

I tried to imagine where the trenches and pillboxes had been, where the dug-out had been. My companion too seemed to be in a nostalgic mood: perhaps similar thoughts were passing through his head.

The three of us carried bunches of flowers towards the shelter from which the magnetic blasts were controlled.

The battered remains of machines collected after the last experiment were piled up in a saddle between two hillocks.

«To us these machines are like ammunition for an army,» Osipov said with a grin. «Bombs-scientific bombs which we are letting off in the name of future vacuum energy. The magnetic field in these exploding machines, which survives for infinitesimal fractions of a second, is millions of times stronger than anything known before.»

We walked on with our load of flowers while Osipov continued:

«Vacuum energy is an ingenious thing. Have you heard of the chandelier your friend and I broke up in my office?» he said, turning to me. «The time will come when we`ll be penetrating in between the squares of the periodic table!»

«What do you mean?» I asked.

«He knows», said Osipov, nodding at our companion, who was all but hidden behind a bunch of flowers. «He has found that microparticles can exist only in compensated energy states. But who has said that there can`t be intermediate states in which radiation is produced by the inner binding energy of a microparticle: by the vacuum energy, that is? Who said that stars shine only thanks to the thermonuclear reactions taking place in them? No one has ever been there, and I have no wish to. It`s too hot. And why is it not? Maybe because noncompensated radiation takes place there?»

«That`s extremely interesting», said Ilyin.

«I think so too». Osipov nodded and walked down the steps into the shelter.

I cast a last look about the steppe. Gophers were whistling and a kite circled high in the sky. A breeze carried the smell of the sea.

A dim passage into an underground laboratory. Concrete walls and vault. The smell of fresh paint and burnt insulation. The academician wrinkled his nose. From his looks one could tell that he was in a mood to give someone a dressing down.

A tall, lanky engineers captain with a serious face stood before us.

Osipov ordered him to increase the explosive charge several times. The captain clicked his heels and left, casting a sidelong glance at the bunch of tulips standing in a bucket.

«This is only the beginning,» the academician exclaimed. «Today we`ll be delighted if we manage to kindle a molecule. Wait till we get down to lighting a second sun over the Polar regions or a submarine one to heat ocean currents! That`ll be something!»

«That will require other kinds of machines,» Ilyin remarked.

«Of course,» the academician agreed. «But our electromechanical charges with their explosive motors will also serve us well.»

And they did.

The tulips had disappeared from the steppe. The grasses had wilted, and hot streams of air rose over them. The outlines of the hillocks quivered nebulously. The chalk cliffs of Feodosia could no longer be seen through the purple haze.

We emerged from the underground laboratory as into a hot furnace. The hot, desolate steppe was quiet. Only when evening fell would the cicadas awaken and commence their endless chirping.

The academician`s young assistants hurried ahead to the pit in which the last explosion had demolished the instantaneous action electric machine. Its power, we had been told, was now thousands of times greater than in the first experiments.

We were going to see its remnants, all that was left of the stator and rotor, though in this machine they did not exist in the conventional meaning.

The young people up in front halted at the edge of the pit.

«Come, come, boys», the academician hurried them. «See that the pit is cleared for the next blast».

«There`s no need», said one of the engineers. «Now there`s no need».

«What do you mean there`s no need?» Osipov said angrily. «What are you beaming about?»

«It`s not we who are beaming, Andrei Gavrilovich. It`s in there».

«I can`t see anything,» Osipov said, shoving impatiently past them.

«Come over here, Andrei Gavrilovich. That fragment is in your way. See it now?»

«It`s glowing!» Osipov exclaimed with youthful fervour. «By god, it`s glowing!»

«Perhaps it`s some incandescent particle left by the explosion», Ilyin suggested cautiously.

«They`re always like that, the theoreticians!» Osipov exclaimed with mock indignation. «Incandescent particle indeed, when the eyes can`t stand its light! And you a former artillery officer! Do you realize that the particle is radiating!?»

Ilyin and I could now see that in spite of the bright sunlight a blinding little star was gleaming among the smouldering black fragments of the machine.

Academician Osipov`s working days became an endless holiday to him. Instead of leaving, as Ilyin and I had planned, we remained at the «magnetic proving ground.»

The «star» was removed from the pit with the utmost care. It was smaller than a grain of sand, but when it touched the sun-dried grass it set it on fire. Smoke drifted over the steppe.

The little «star» had to be transferred to an underground vault into which access became possible only in heat resistance suits. Precision instruments measured the exact amount of calories radiated by the molecule.

Ilyin sat at a table in a tent pitched behind the hillock and did sums. He was, in fact, laying the foundations of the future theory of vacuum. Academician Osipov walked over to him every once in a while and they discussed something in excited voices. In fact, the academician was the vociferous one; Ilyin, as always, spoke in soft, even tones.

«Hot as a furnace!» the academician announced gleefully. «This, my dear fantasy writer, is already a technological solution of the problem. Any number of such "stars" can be lit. This is a revolution in world power production! Every such speck will glow for centuries». He pointed at the vault. Streams of hot air flowed up from the steps leading down to it.

But even this was not enough for the impatient Osipov. To him the «star» was only the first step.

He was already dreaming of a new Great Geography of the globe created by man, in his mind`s eye he already saw a huge electrical machine powered by a mighty nuclear blast and lifted by a rocket into the orbit of an artificial satellite. At an altitude of several thousand kilometres in outer space a harmless nuclear trigger explosion would take place, almost all the energy of which would instantaneously go into a magnetic field. And then a new, «vacuum» sun would light up above the earth.

The academician already saw it rise and set with the real one, but its rays, instead of sliding over the surface of the polar regions, fall almost vertically, without dissipating their heat in a thick layer of atmosphere, and they warm the North evenly, creating a temperate climate. Osipov`s imagination then saw a magnetic explosion under water. The «submarine sun» it kindled there would warm sea currents, altering the earth`s climate according to plan. He was not dismayed by the prospect of the rising of sea level, for the continents can be fenced off by ice levees.

The geography of earth would change. The notorious power hunger would be done away with once and for all. For the energy reserves locked away inside the molecules of every substance can never be exhausted.

Possibilities

My old friend finished the last page of the manuscript.

«Oh, Sasha, Sasha,» he said deprecatingly. «You incorrigible day dreamer! But you`ve overlooked the main thing.»

«You mean I haven`t seen far enough?» I asked, surprised.

«I didn`t say that. I said you overlooked the main thing. You`ve written about vacuum energy, but you`ve forgotten about the vacuum.»

«What do you mean?»

«You`ll recall that your army friend postulates (Osipov, it seemed, had already studied the physicist`s work, published by the Pulkovo Observatory) that vacuum is made up of coalesced mirror particles. What does that mean?»

«That they can be separated, I suppose».

«Right. Vacuum can be excited».

«But this would take a very great expenditure of energy».

«On what level? On the nuclear level. If we manage to excite vacuum we will obtain microparticle pairs apparently out of nothing, though actually out of the latent material substance which vacuum represents. These microparticles can then be used to release their microbinding energy on the new level of vacuum energy, which is several orders of magnitude greater than the nuclear energy expended in exciting the vacuum».

«In other words you think that energy can be got out of nothing?»

«Only people with nothing inside their heads can say such a thing. Not out of nothing, but out of vacuum, which is made up of quanta of matter which represent... what?» he drilled me with a questioning glance.

«Coalesced particles and antiparticles».

«Right».

«And more: you, a man engaged in interplanetary affairs, haven`t taken into account that stellar flight can then be powered by the vacuum energy of space, the vacuum through which you fly.»

«So you believe now in vacuum energy?»

«We`ll start producing vacuum energy, then we`ll see. Incidentally, the astronomers have put forward a theory concerning higher cosmic civilizations, classifying them in three groups. The first is analogous to earth in "respect of power supplies"; the second utilizes the total energy of its luminary; the third uses the energy of the whole galaxy. I had treated this as nonsense. How was one to utilise the energy of stars separated by thousands of light years? But now it is different. If one is not just a passive consumer of the universal radiation and kindles suns of vacuum energy for oneself then there are no visible limits to the expansion of energy supply. Evidently such a civilization can be ranked as the highest, capable of generating unlimited power supplies. Not a bad prospect for mankind!»

«Wait a moment, Andrei. You told me to do some dreaming to solve....»

«What`s there to solve? Fetch your theoretician. And remember that only that theory is valid which opens up vistas for further development of science, for new flights of fancy, for new quests and achievements and doesn`t lead knowledge up a blind alley. That`s how it is, my dear fantasy writer».

He slapped my back.

I think he expressed the meaning of Niels Bohr`s «testament» most exactly.

Translated by Vladimir Talmy

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