Boris Chirikov - Sputnik of Chaos

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In Russian, the word *Sputnik* means companion. But after the very first artificial satellite *Sputnik*, launched back in 1957, this word became also a metaphor for a pioneering, outstanding achievement. These meanings are appropriate for a portrait of Boris Chirikov, who was the founder of the physical theory of Hamiltonian chaos and made pioneering contributions to the theory of quantum chaos. In 1959, he invented a simple analytical criterion, now known as the Chirikov criterion, which determines the conditions for emergence of deterministic chaos in dynamical Hamiltonian systems. His biography and scientific achievements can be found in the Scholarpedia and Wikipedia articles dedicated to Boris Chirikov. These sources also provide various links to additional material available on the web. Here I give my personal reminiscences about my teacher Boris Valerianovich Chirikov.

A Master's Touch. I joined Chirikov's group at the theory division of the Institute of Nuclear Physics (INP) in September 1976, at the beginning of my 4th year at the Novosibirsk State University. At the University, it was common practice to attach students of this year to specific research Laboratories or groups at the Academy Institutes at Akademgorodok. As many other students, I knew Chirikov from the course of Electrodynamics given by him and I. N. Meshkov at our second year. But my choice was also significantly influenced by a recommendation of George Zaslavsky, whom I knew, who had worked with Chirikov and gave outstanding recommendations for his research. Also Chirikov was favourable to have a new student and had that possibility from the INP side.

Chirikov was head of the sector T3 of the theory division directed by Spartak Belyaev. The division was composed of three sectors, and there were about ten people in T3. However, the actual group working with Chirikov on nonlinear dynamics and *stochasticity* (now we say *chaos*) was rather small; it included essentially Felix Izrailev, Vitaly Vecheslavov and Lida Hailo, who worked as a programmer. Two young researchers soon moved from T3 to other Laboratories of INP: Valery Tayursky to Lab3 and Oleg Zhirov to T1, to continue work with E.Shuryak.

I remember Chirikov's office in 1976-1978. It was a small room of $12m^2$, located on the fifth floor at the back yard of the main INP building. There were three desks of Chirikov, Izrailev, and Zhirov. The main focus of the room was a teletype terminal directly connected to a computer BESM-6 at the Computer Center of Siberian Division of Russian Academy of Sciences, located at about 1km distance down along prospect Nauka.

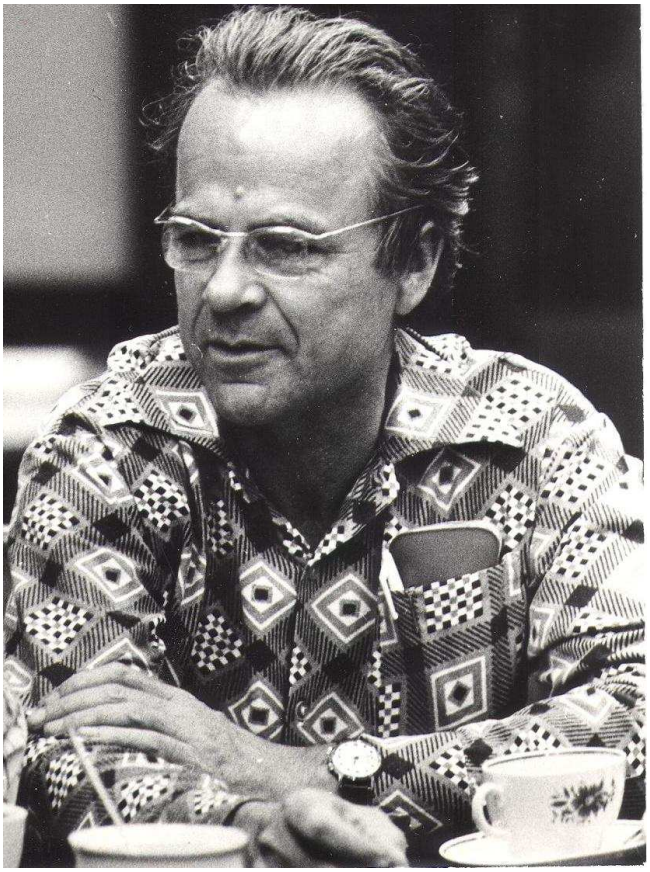

FIG. 1: Boris Chirikov at the round table, INP, around 1978 (photo by V.Petrov, INP).

This was the most powerful soviet computer at that time. From the terminal it was possible to submit short runs on BESM-6, and even to work in interactive mode. The terminal produced a deafening rumble, but everybody in the group —especially Chirikov— was proud of it. A photo of Chirikov of that period is shown in Fig.1.

Fundamental Laws. The first topics of study proposed by Chirikov were linked to dynamics and chaos of nonlinear chains, related to works of N. Zabusky, and to chaos border in the standard map, related to works of J. M. Greene. From time to time I was going to his office to discuss my progress. In the spring of 1977, at the end of such an evening discussion, Gennady Dimov came, saying that he had important things to discuss with Chirikov. I stood up to leave the office, but Chirikov asked me to stay. Dimov was doing experiments on plasma confinement in magnetic traps, and he

had recently invented a new ambipolar trap (AMBAL). He proposed to Chirikov and his group to start research on this project, doing numerical and analytical investigations of the complex particle dynamics in such type of traps. This proposal was supported by Budker, the founder and director of INP. Chirikov's answer was rather characteristic. He said:

> "The AMBAL project is very interesting: I am ready to provide all my expertise, and I'll make certain studies of particle dynamics by myself [he really did this]. However, I will not engage my group in this line of research, since our main aim is the investigation of fundamental laws of chaos and foundations of statistical mechanics for classical and quantum systems."

Looking back, I think that this story highlights several things about Chirikov: his wish to help the broad research aims of INP, to continue the fundamental research directions of his group, and to defend the research freedom of his close collaborators.

Quantum Standard. In 1977, the now famous kicked rotator model was invented. This simple model is the quantized version of the classical standard map, now known as the Chirikov standard map. The classical and quantum models became the corner-stones of the well established fields of classical and quantum chaos. But in 1977, many people looked at the quantum model with suspicion. I remember that the usually heated atmosphere of the theory seminar (see photos in Fig.2), became a typhoon when Chirikov presented the results on kicked rotator for the first time:

> "Why you have here a delta-function? Why does your spectrum grow quadratically with the level number? Why does the energy of your quantum system grow slower than in the classical system, while the quantum theory is probabilistic?..."

Only Chirikov understood that the standard map describes a generic behaviour of chaotic systems, and since the correspondence principle, invented by Niels Bohr, should be valid at small dimensionless values of Planck constant, the kicked rotator model should demonstrate generic properties of quantum systems chaotic in the classical limit (now we say properties of quantum chaos). And indeed, the kicked rotator demonstrated a generic phenomenon now named dynamical localization (I would name it Chirikov localization). An analytical estimate of the number of populated quantum states, which is essentially the localization length, was obtained by Chirikov and his group at INP in 1980-1981. However, the analogy with the well-known phenomenon of Anderson localization was established by the Maryland group of Fishman, Grempel and Prange in 1982. Weak links with the solid state groups in Akademgorodok were probably the reason why our group missed a part of the story.

FIG. 2: Boris Chirikov and INP theory division, June 6, 1988 (photo collage dedicated to 60th birthday of Chirikov, collected by Ryta Ryutova with help of Lida Hailo and DLS).

Back in the late spring of 1977, Chirikov suggested that I work on the kicked rotator model, starting from the improvements of the computer code. Following his suggestions, I achieved a significant reduction of the CPU time, and I am still proud that the improved figures we obtained, were used in the Russian version of the kicked rotator paper written at INP and published as INP preprint in 1978. The English version published in 1979 was based on a presentation of this work given by foreign co-authors at a conference in Italy in 1977. In fact, there were significant differences from the Russian version, since communications between the USSR and the West were rather slow at those times. About a quarter of a century later, in a discussion about quantum chaos, kicked rotator and Chirikov, Oriol Bohigas (Orsay) pointed to me

> "Boris must have been thinking very deeply about all these things, to invent such a model."

Our Chaos Is the Best in the World. In the summer 1978 I graduated from the University, and became a stagier at INP, and soon a PhD student under Chirikov's

supervision. In the fall of 1978 the theory division moved to the top floor of new building behind the main one. The development of chaos theory had great potential for expansion, in the USSR and abroad. In Chirikov's group we were enthusiastic, and completely sure that our chaos was the best in the world.

Indeed, at those times even chaotic dynamics in nonlinear classical systems was a rather new and unusual subject for the world scientific community. For example, there wasn't any specialized journal in this field (now there are about ten), and often it wasn't easy to explain to an editor how it happens that, in spite of Laplace determinism, simple equations produce chaotic unpredictable behaviour. Quite often, editors blamed errors of numerical simulations, and rejected papers on chaos. The world wide circulation of research results was initiated by Joe Ford at Georgia Tech, Atlanta, who, every week, patiently collected the abstracts of new preprints on chaos and nonlinearity, and send them to colleagues and friends. Chirikov knew Joe Ford from their first meeting in Kiev in 1966, where Ford came as a tourist with a group of school pupils to visit the USSR. From that time they continued a regular correspondence (available at the archive of Boris Chirikov) and of course the world chaos news were regularly sent to Chirikov in Siberia. Finally, the number of publications in nonlinear systems became so large that the first specialized nonlinear journal, Physica D, was created in 1980. During many years Ford and Chirikov worked in the editorial board of this journal. It was Joe Ford who also stimulated Chirikov to write his famous chaos review article, in Physics Reports in 1979. At present, this is the most quoted single author article of Russian scientific research (see www.scientific.ru).

This was the situation with classical chaotic dynamics. At that time, there were only few people in the world working in field now known as quantum chaos. Besides the Chirikov group, there were Martin Gutzwiller at New York and George Zaslavsky at Krasnoyarsk. But the interest in this field was rapidly growing all over the world. Also in the theory division Dodik Shuryak, Sam Heifets and Valya Sokolov obtained interesting results, and followed closely the development in the area. One of the important results, coined by Chirikov as the Shuryak border for quantum stability of chaos, still makes people happy at Stony Brook, NY since the border moved there from Siberia in 1989.

Chaos Easy to Discuss. Classical and quantum chaos were attracting the interest of various people. The spectrum of visitors in Chirikov's office was very broad: there were Soviet scientists from many cities, jobless physicists, foreign researchers from many countries, including East and West Germany, France, Italy, UK, USA. Chirikov often invited his group to follow a discussion. He had the same attitude towards any visitor, and never blamed a speaker for not knowing some well-known things. He used to say:

> "Criticism should be constructive"

and he always tried to extract some positive things from a talk. That's why people felt themselves at ease to ask him about any scientific problem; this it is nicely illustrated in the reminiscences of Igor Meshkov. Even Chirikov's office reflected his simple working attitude: it was very modest, with a plain old desk, old chairs, and book-shells.

What is even more surprisingly is that Chirikov was able to communicate not only with physicists, but also with mathematicians and philosophers. After his visit to Kolmogorov in 1958 (see the Scholarpedia article), he maintained close contacts with Vladimir Arnold and Yakov Sinai and other members of this school. He was able to understand their formal theorems, tried always to extract their physical meaning, and applied them in his own research. I remember how Chirikov was telling me

> "Of course, it's usually very difficult for a physicist to read and understand a mathematical paper, but when you corner a good mathematician, like Arnold or Sinai, and discuss closely his results then, he will start to explain them to you as a physicist!"

At the celebration of Chirikov's 65th birthday, Sinai proposed a special toast for Chirikov and his respect for, and links to, mathematicians.

As to philosophy, it suffice to say that Chirikov published some articles in philosophy journals in German, English and Russian, and was respected by philosophers both in the USSR and in the West, even if both sides usually did not respect each other. His talks at the philosophy seminar of INP were always attracting a full audience of the large conference hall of INP. I remember his aside note during such a talk:

> "The human mind is weak, and it needs a prompt to understand complex behaviour. Numerical simulations on a computer, or numerical experiments, give such a prompt. But computers have restricted abilities, and hence a researcher should find a good model, which on the one hand is sufficiently simple for simulations, but on the other captures the generic properties of the phenomenon being investigated."

I think that the very best example of such a model is the Chirikov standard map, which is still has puzzling phenomena in both classical and quantum cases, and which is still actively investigated in modern experiments with cold atoms and Bose-Einstein condensates.

Supercomputer Fervor. Computers were one of Chirikov's passions. At a very early stage, in the be-

ginning of the 60s, he realized their importance for investigations of dynamical chaos, and since then used them extensively in his research. Back in 1979 Chirikov was allowed to make a return visit to Joe Ford at Atlanta for three months, (Ford had visited Chirikov earlier in 1979). During this visit he got access to the most powerful computer of that time, the CRAY I. His work on CRAY I is lively described in the reminiscences of Franco Vivaldi, while I know only how it was after his return back to INP. The first thing Chirikov showed to me was a white sheet of paper on which there was a hand-drawing of an american phone handset. He compared this image with a phone handset in his office, and concluded that in principle it was possible from Siberia to make computer runs on the CRAY in the USA. The attraction of CRAY was very strong, since Chirikov established that it was 500 times faster than BESM-6. It looked like a fantasy at that time. About two or three years later Jeff Tennyson, visiting INP, managed to establish a short connection with a CRAY in the USA, but it took about nine years before a real work on CRAY in Europe became possible during visits of foreign colleagues to the Chirikov group.

Chaos vs. Order. After Chirikov's return from the USA I continued with him our chaotic research. We discovered a slow algebraic decay of Poincaré recurrences in generic chaotic maps, presented at the International Conference in Kiev in 1981. We also showed that homogeneous classical Yang-Mills fields have a chaotic dynamics, which shattered a dream of V. E. Zhaharov about the integrability of such all important equations in physics. Surely, a chaotic behaviour is generic while an integrable one is rare and exceptional. Chaos gains vs. Order but then again Order emerges from Chaos. But the main research line was linked to quantum chaos and the kicked rotator. A global picture of time scales in the regime of quantum chaos has been worked out and presented in the review of 1981 written by Chirikov, Izrailev and myself. Soon after that, in 1982, I defended my PhD and became a permanent researcher in Chirikov's group.

Chaotic Translation. In 1983 Chirikov had a very short visit (a couple of days) of Michael Lieberman from Berkeley. With Allan Lichtenberg, who had already visited Chirikov at INP around 1977, they were preparing for publication their fundamental book on chaotic and regular dynamics. They wanted to know Chirikov's comments, and he had quite a few of them, since I remember seeing some pages of the manuscript with many marks of his red pencil. In addition to that Chirikov found time to discuss the behaviour of modulational diffusion in chaotic systems, which were finalized two years later in a joint work of Chirikov, Lieberman, Vivaldi and me. In fact Franco Vivaldi became so addicted to Akademgorodok and Chirikov that with his wife they even have spent a part of their honeymoon in Siberia in 1984!

In spite of all his comments, Chirikov thought that the book of Lichtenberg and Lieberman was really good, and should be translated in Russian. The publisher Mir agreed to publish it. The whole group started to work on this translation under Chirikov's supervision, using an unpublished copy brought by Lieberman to INP. The work was finished in the spring of 1984, very soon after the appearance of the English original, published by Springer in 1983. Chirikov sent me with the final translation to Mir, Moscow. I arrived there and gave the manuscript to the Editor of Mir. He looked through the translation for few minutes, then jumped up and cried:

> "I cannot engage Mir to publish such a chaotic translation! It will be an international scandal! This does not comply with international agreements! Almost every page of your translation contains a note of the translation Editor (Chirikov)!"

I nearly failed to convince him, and only after I told the story of how Lieberman visited Chirikov while preparing the Springer publication, Mir's Editor realized the importance of these corrections and accepted the translation which was quickly published by Mir in 1984. After that we received compliments of Lichtenberg and Lieberman, who took into account the complements of Chirikov in the second edition of their book published in 1992.

Chaos Summits. In 1983 Chirikov became a corresponding member of the Academy, and the development of chaos theory continued to expand to a higher level. During this year I developed a computer code which allowed to simulate an unexpectedly strong ionization of hydrogen atoms in Rydberg states by a microwave field, which was first observed in experiments of James Bayfield and Peter Koch at Yale in 1974. In contrast to the classical numerical simulations of Ian Percival done in London in 1979 (in fact Percival visited Chirikov during summer 1983), my quantum simulations were showing, under certain conditions, the quantum suppression of classical chaotic excitation, which was rather similar to that seen in the kicked rotator. With a help of our american and italian colleagues, the following year this code was run on a CRAY at Livermore. The improved data were analysed in detail in Siberia, and explained on the basis of the dynamical localization theory developed for the kicked rotator in 1981 and later. Finally, the analytical theory combined with numerical data was published by Casati, Chirikov and me in Phys. Rev Lett. in 1984. This was a first application of quantum chaos theory to a real system studied experimentally. Further studies showed that this system is locally described by the quantum Chirikov standard map, and that the dynamical localization should be observable in experiments with a higher microwave frequency. During the workshop in Riga and the Vavilov Conference in Novosibirsk in 1987, Chirikov and I succeeded to convince Koch to

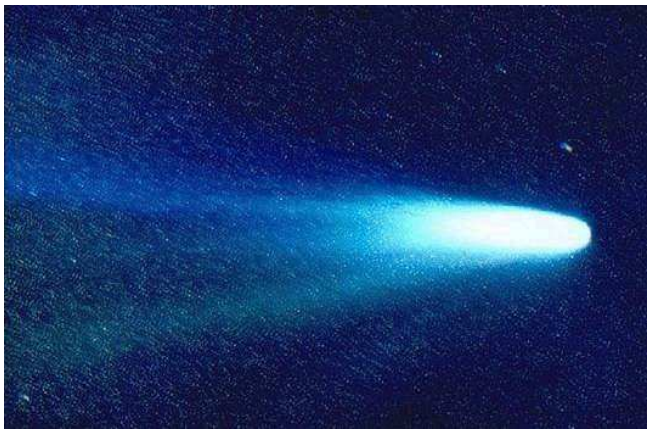

FIG. 3: Comet Halley, 1986 (image from http://users.telenet.be/Astronomy_Coins_Medals)

make experiments in those conditions, and the theoretical predictions of dynamical localization theory were observed by his group at Stony Brook in 1988.

In 1988 Chirikov and Vecheslavov, exited by a recent appearance of Halley's comet in 1986 (see Fig.3 and Wikipedia), performed an analysis of its 46 apparitions known from historical records and computer simulations and showed that the comet dynamics is described by a simple area-preserving map which is rather similar to the standard map. The dynamics of the comet was shown to be chaotic with a typical life time of 10 million years. This was an amazing example of an enormously rich information extracted from only 46 numbers!

In 1988 INP celebrated Chirikov's 60th birthday with coffee, tea and songs at the round table, photo collage of theory division, directed now by Chirikov (see Fig.2), and other festivities. At that time quantum chaos became a popular field of research, and a special Les Houches Summer School was organized in France in 1989 on that subject. Chirikov gave there a fundamental course on quantum chaos in time-dependent systems, Izrailev and I gave short courses. We met there many leading players in the field, whom we knew before only through their pioneering publications, including Oriol Bohigas, Martin Gutzwiller and many others. A few speakers, like M. V. Berry and I. Percival, were already known to us from their visits to Akademgorodok.

In the next two or three years quantum chaos flourished, with a variety of international workshops, schools and conferences organized in various countries. The manifestations of quantum chaos have been observed in various experiments in atomic and mesoscopic physics. But in spite of this experimental progress, it was becoming clear that the main effects of one-particle quantum chaos became understood at the end of second Millennium. It was a time to look for new ideas and lines of development of this field. In 1991 I got one year CNRS invitation to Toulouse and went there. A couple of months later the USSR disappeared. I got a research position at CNRS and continued to work in Toulouse. My visits to Akademgorodok persisted once a year.

In 1992 Chirikov became a full member of the Academy.

French Connections. In 1993, Jean Bellissard, the leader of the theory group in Toulouse, and I succeeded in organizing a two month visit of Chirikov and his wife Olga Stepanovna to Toulouse. They arrived in December, 20 years after a virtual visit of Chirikov to Toulouse. Indeed, he was supposed to give an invited talk at a CNRS Conference on chaos theory in Toulouse 20 years earlier, but did not get a soviet permission as it was often the case at those times. His talk on dissipative dynamical chaos was presented by Joe Ford and was published in the Conference Proceedings. It appears that these results of Chirikov and Izrailev stimulated M. Hénon, who was among conference participants, to invent the Hénon strange attractor.

During this visit to Toulouse, Chirikov wanted to understand the physical meaning of a theorem proved by A. I. Shnirelman in 1975. We found a simple dynamical model and our studies led us to a nice physical interpretation of the Shnirelman peak in the level spacing statistics: it appears due to tunneling between the future and the past!

Meanwhile, Olga Stepanovna, who speaks only Russian, succeeded in communicating nicely and simply with the inhabitants of Toulouse, who were speaking only French. She was explaining us her method:

> "In a shot, I just tell them in Russian very clearly what I need, and the owner very rapidly brings me this thing!"

Definitely, such a method could work, but only when you are a professional Russian actress with a long carrier behind you!

We did few joint trips around Toulouse, Chirikov and Olga Stepanovna visited Paris. During our evenings together there were plenty of stories about their other trips in the USSR, usually with Olga's theater tours. Here is one of them: open fields in Kazakhstan, only a small old building on the entrance to a forbidden area, but an officer at the entrance tells a theater representative

> "Don't worry, underground we have a new military complex with a large conference hall for your performance."

The names of the people being admitted were in a special listing of some theater staff. The officer reads the list, with a name and a profession for each person:

> " Bashina, profession - actress, go ... Ivanova, profession - actress, go ... Chirikov, profession - husband ?!"

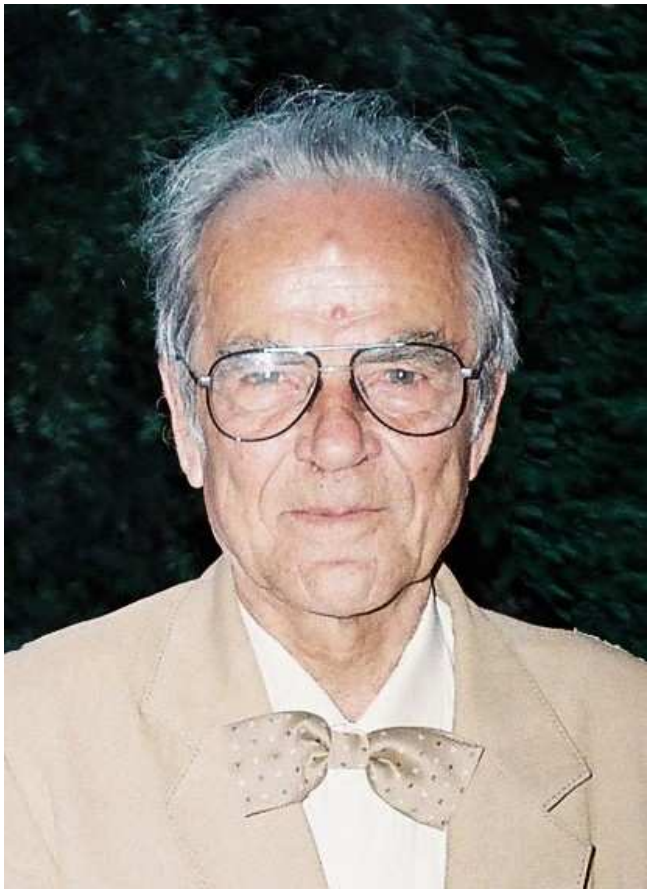

FIG. 4: Boris Chirikov, Toulouse, June 6, 1998 (photo by DLS).

Laughing, special checks, explanations that he is also a physicist working in the Academy, then ... go!

Chirikov and Olga Stepanovna came again to Toulouse in 1998. Chirikov's 70th birthday was celebrated on June 6 with enormous amount of greetings sent to him from all over the world. A photo of this day is shown at Fig.4. The next day Chirikov took all the greetings and personally thanked everyone. During this visit we worked on our old problem of Poincaré recurrences in area-preserving maps. The results in the form of poster were presented at the International Conference dedicated to 70th of Chirikov organized in Toulouse on July, 16–18. About a hundred of participants came from Europe and countries as far as Australia and USA. During the Conference banquet, Peter Koch gave the after dinner speech and read the special greeting from the President of American Physical Society Andy Sessler (see reminiscences of A.Sessler and P.Koch). A special plate "X Chirikov Chaos Commandments" signed by invited speakers and close friends was given to Chirikov as a present (see the Scholarpedia article).

After the Conference Chirikov and Olga Stepanovna went to Paris where Chirikov participated in the work of STATPHYS Conference. They spent a week there staying with the family of Oriol Bohigas. This was the last visit of Chirikov abroad.

Land Siberia. Back in Siberia Chirikov continued to work on classical and quantum chaos. But with time he became increasingly interested in the properties of classical chaos, especially of Arnold diffusion. With Vecheslavov they found unusual properties of chaos in the Nekhoroshev diffusion regime, and in the fractal diffusion in smooth dynamical systems with virtual invariant curves. I was coming to Akademgorodok usually once a year. We continued our studies of Poincaré recurrences which still remains a puzzle of chaotic Hamiltonian dynamics with a few degrees of freedom.

But my main interests were moving more into the direction of quantum chaos in many-body systems, including quantum computers. Our Quantware group in Toulouse showed that quantum computers can simulate evolution of the Chirikov standard map in quantum and classical regimes, in a polynomial number of operations, contrary to an exponential one on classical computers. In the fall of 2002, I brought to Chirikov (see Fig.5) a number of reprints of my recent publications, being proud of several of them published in Phys. Rev. Lett.. Chirikov looked at them, and told me with his kind and ironic smile (see Figs.3,4):

> "Well, you like to publish in Phys. Rev. Letters ..."

Indeed, he belonged to a generation who was presenting their results in secret reports, some of which remained unpublished forever. That's why for him a publication of a preprint of INP, which eventually could even be sent to colleagues abroad, or a presentation at a conference with a publication in Conference Proceedings was considered as quite sufficient. And I think that, broadly speaking, he was right: "manuscripts do not fire" wrote Bulgakov in "Master and Margarita", and this is really true in our electronic century! A good work will find his readers, and I am glad that even old and hardly accessible publications by Chirikov are now available to everyone via the web: it is sufficient simply to type "Boris Chirikov" on Google.

Chirikov's 75th birthday was celebrated at INP by the International Conference in his honor hold in summer of 2003. Many his old friends came to INP including Yuri Orlov and Andy Sessler. I had problems with my Russian passport exchange and unfortunately was able to come to INP only in October. When I entered in Chirikov's office, he smiled and said:

> "It's even better that you came now, it's much quieter, and we will have more time to discuss science."

He was passionate about his new approach of "Creating chaos and Life", which appeared later as arXive:physics/0503072. This was a further development

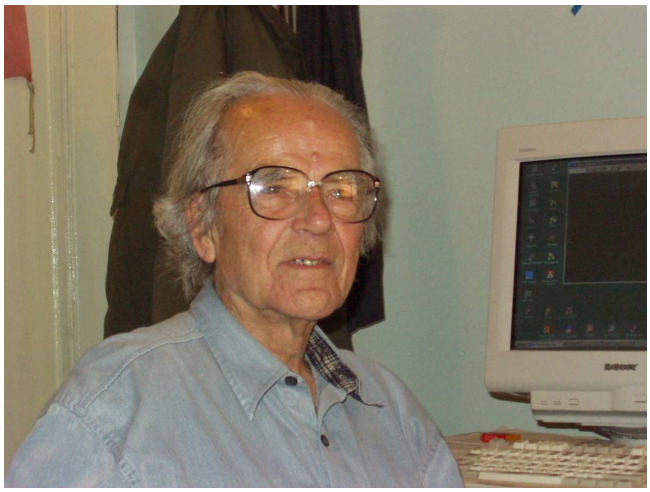

FIG. 5: Boris Chirikov in his office at BINP, September 2002 (photo by DLS).

of his philosophical work presented at the Conference "Law and Prediction in the Light of Chaos Research" in Salzburg in 1994. An important stimulus came also from his discussions with Yuri Orlov during their meeting in 2003, which he recalled with enthusiasm. In this work of 2005, Chirikov presented his main idea:

> "The source of new information is always chaotic. Assuming farther that any creative activity, science including, is supposed to be such a source, we come to an interesting conclusion that any such activity has to be (partly!) chaotic."

He questions how this creative side of chaos is combined with the so-called *human freedom of will*, and the functioning of human brain. Definitely, this fundamental problem will continue to attract research interest in future.

During our meetings at INP, and at his home, Chirikov told me many stories about Budker, Kurchatov Institute and INP history, his meetings with Kolmogorov, Ulam and other leading scientists (see some of them at the Scholarpedia article). Other stories were about the Second World War, the siege of Leningrad and his mother and him evacuation from Leningrad to the Krasnodar region, soon occupied by the German army around 1942–1943. A characteristic story of that time he told me:

> "A wounded Russian partisan hid in our home, and a german soldier came in for a search. I was alone at home, the situation was critical, and I was preparing to use one of the grenades I was hiding at home. The soldier came to a table in the center of the room, saw a soviet school manual of German language there and opened it. Then he spat, cursed, and went away. I looked at the opened page of the manual, it was the song text of the International!"

In the late fall of 2007 the Editor of Scholarpedia commissioned us to write an encyclopedia article, which he entitled "Chirikov standard map". I came to Akademgorodok with a draft in January 2008. A strong frost below -35 C was covering the science town. Chirikov was not feeling well. Our last meetings were at his home. On the last meeting, there were reminiscences about Chirikov's last stay at Paris chez Bohigas. Olga Stepanovna found notes of Russian songs, and I was asked to bring them to Bohigas, as a reminder of their visit to them ten years ago. The article was submitted to the Editor during the first week of February. On February 12, 2008 Boris Valerianovich Chirikov passed away.

Memorial Seminar. The sad winter came to an end. Spring was coming and the Budker Institute of Nuclear Physics was organizing the Chirikov Memorial Seminar, linked with the celebration of the 50th Anniversary of INP in May 2008.

While preparing my talk for the Seminar, one day in April, I heard a news announcing that Edward Lorenz, father of chaos theory, died at 90. It was in TV news across the world, and appeared everywhere on the web including Russian sites such as Lenta.ru. Definitely, in 1963 Lorenz performed very important and profound studies of dissipative chaos and invented the important model which is now known as the Lorenz attractor. But this was well after 1959, when Chirikov freed the genie of Chaos, which spread the world over.

I came to BINP few days before the Seminar, and had time to look through the archive papers left by Chirikov. They were well ordered in a few folders. One of them was named "ITOGO" (results, resumé). There were several selected notes. In the first place, there were two stenographic notes from his candidate and doctor thesis defenses. The second event was dated by March 12, 1969 and I opened its notes. The President of the Council was academician Budker, teacher of Chirikov. His short note at the end of the Council discussion brightly highlighted the atmosphere of this period of scientific expansion, with its difficulties and its discoveries. I finished my talk at the Seminar by reading these words of Budker in the same hall where he had told them years before:

> "Anyone wants to make a note? No one. In such a case, let me say a few words. Here, in the thesis, it is written that the candidate for a degree (candidate) is thankful to Budker, among others. This is not right; no one put so much effort to prevent the candidate from doing this thesis as I did. Chirikov is a good experimentalist, thoughtful, and capable to make things, and those experiments which he made were very good, elegant experiments.

Then he got a passion to do theory, and that was his mistake. Thus, all this nice presented work became a consequence of a fatal mistake in the life of candidate. The only thing that could justify this would be its usefulness and value for science. And all we, members of the Council, should take this usefulness into account during our vote.

Of course, if a candidate worked in Saratov or Voronezh University, it would be difficult to dispute the rationality of his choice, to which he devoted many years. But with such a variety of experimental possibilities as there are here, it was not very rational to abandon everything and start doing theory. Indeed, there are more theoreticians than experimentalists. An experimentalist who well understands the theory is a rare and valuable phenomenon. A physicist should not do the same thing throughout his life; this is bad, he will then be a narrow specialist who knows only one thing during all his life. A physicist with broad views should change direction after 5-7 years of work, and this is justified. Any creativity is poetry, art, and not only science, and too long permanency leads to a narrowing of horizon. I want to express my opinion. A break appeared in the biography of the candidate, and from now on he will work in a new field of physics, he has enough experience for that."

All votes approved the defense, as the thesis presented pioneering results in science.

Boris Chirikov is the Sputnik of Chaos. His life is like the light of a comet, showing us the way forward.