Boris Valerianovich Chirikov

From Scholarpedia

Dima Shepelyansky (2008), Scholarpedia, 3(10):6628. doi:10.4249/scholarpedia.6628 revision #78440 [link to/cite this article]

Curator: Dr. Dima Shepelyansky, Laboratoire de Physique Théorique, CNRS, Université Paul Sabatier, Toulouse

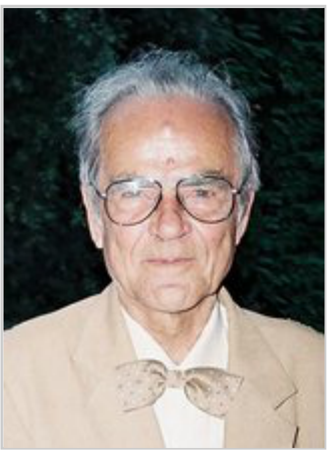

Figure 1: Boris Chirikov, June 6, 1998

Boris Valerianovich Chirikov (Russian Борис Валерианович Чириков), born 6 June 1928 in Oryol, Russia, USSR, died 12 February 2008 in Akademgorodok, Novosibirsk, was an outstanding Russian physicist. He was the founder of the physical theory of Hamiltonian chaos and made pioneering contributions to the theory of quantum chaos. In 1959, he invented the Chirikov criterion, an analytical method to determine the conditions for emergence of deterministic chaos in dynamical Hamiltonian systems.

Contents

- 1 Life and Physics
- 2 Chaotic Stories
- 3 References
- 4 External links
- 5 See also internal links

Life and Physics

B.V.Chirikov's mother was Chirikova Lidia Vasilievna, who worked as a teacher, pedagogue, and librarian. His father, Leronskii Valerian Nikolaevich, left the family and Boris did not remember him. Their small family lived in Oryol approximately until 1936 when they both fled famine and went to Leningrad, where one of his mother's sisters helped them to settle. They lived there until the war. Around 1942, with other children who were attended by the mother, they were evacuated from Leningrad to the southern region of Russia around Krasnodar. About four months later this region was occupied by the German army, and they lived under occupation, to be liberated by the Soviet Army in 1944. Soon after that, the mother died from leukemia. Fortunately, Boris was helped by a teacher of his school, who took him to her home. After the school was finished in 1945, Boris went to Moscow to continue his studies.

Figure 2: G.I.Budker and B.V.Chirikov, INP, around 1972

Chirikov was admitted to the Moscow Pedagogical Institute, and in the second year became a student at the recently created Department of Physics and Technology at Moscow State University (which later become the Moscow Institute of Physics and Technology, MIPT). He did his undergraduate and master studies there, and continued his experimental studies at the Thermotechnical Laboratory (TTL), later evolved into the Institute for Theoretical and Experimental Physics (ITEP). After graduating from the Moscow Institute of Physics and Technology (http://en.wikipedia.org/wiki/Moscow_Institute_of_Physics_and_Technology) in 1952, for few years Chirikov was involved in the study of meson physics at the TTL. In 1954 he accepted the offer of Gersh Budker (http://en.wikipedia.org/wiki/Budker) , at that time Head of Laboratory of Novel Acceleration Methods, to join his group at LIPAN (currently the Kurchatov Institute (http://en.wikipedia.org/wiki/Kurchatov_Institute)) and to start working on problems of accelerator and plasma physics. In 1958 Budker founded the Institute of Nuclear Physics (INP) in Akademgorodok, Novosibirsk (now Budker Institute of Nuclear Physics (http://en.wikipedia.org/wiki/Budker_Institute_of_Nuclear_Physics)). Chirikov became the member of the INP at April 15, 1958, the same day as Budker. He moved to Siberia in September 1959. Since then and until his last days, he was working at the INP, first as an experimentalist, and then gradually evolving into a world class theoretician. He became a corresponding member of the Russian Academy of Sciences (http://en.wikipedia.org/wiki/Russian_Academy_of_Sciences) in 1983, and a full member in 1992. Chirikov contributed much to the teaching of physics at the Novosibirsk State University (http://en.wikipedia.org/wiki/Novosibirsk_State_University) , where he began to give lectures immediately after the university's foundation in September 1959. His lectures attracted to physics hundreds of students around the world. He is survived by his wife Olga Bashina and daughter Galya Chirikova.

The name of Boris Chirikov is associated with an impressive list of fundamental results in the field of dynamical chaos, and the foundations of statistical mechanics. As early as 1959, in a seminal article, Chirikov proposed a criterion for the emergence of classical chaos in Hamiltonian systems, now known as the Chirikov criterion (Atom. Energ. 6: 630 (1959)). In the same paper, he applied this criterion to explain some puzzling experimental results on plasma confinement in open mirror traps, or magnetic bottles, that had just been obtained at the Kurchatov Institute (http://en.wikipedia.org/wiki/Kurchatov_Institute) . As in an old oriental tale, Chirikov opened such a bottle, and freed the genie of Chaos, which spread the world over. In fact, this was the very first physical theory of chaos, which succeeded in explaining a concrete experiment, and which was developed long before computers made the icons of chaos familiar to everyone. In the early 1960's Chirikov understood the importance of numerical experiments for the research of chaotic dynamics and used computers intensively to understand deep the properties of chaos.

Figure 3:

Other results obtained by him with his group at INP include: the determination of the strong chaos border and the explanation of the Fermi-Pasta-Ulam problem; the derivation of the chaos border for the Fermi acceleration model; the numerical computation of the Kolmogorov-Sinai entropy in area-preserving maps; the answer on the question of Poincaré about the width of chaotic separatrix layer, investigation of chaotic attractors in dissipative dynamical systems; the investigations of weak instabilities in many-dimensional Hamiltonian systems (Arnold diffusion and modulational diffusion); the demonstration that the homogeneous models of classical Yang-Mills field have positive Kolmogorov-Sinai entropy, and therefore are generally not integrable; the discovery of the power law decay of Poincaré recurrences in Hamiltonian systems with divided phase space; the demonstration that the dynamics of the Halley comet is chaotic, and is described by a simple map.

He (essentially) invented the Chirikov standard map, described its chaos properties, established its universality and found a variety of applications. In 1977, he initiated the investigations of the quantum version of this map, also known as the kicked rotator. This led to a discovery of the phenomenon of dynamical localization of quantum chaos, which can be considered as a dynamical, deterministic version of the Anderson localization appearing in disordered solid-state systems. The research performed by his group established the grounds of the correspondence principle for dynamics of quantum chaos systems, and showed that the classical chaos survives only on the logarithmically short Ehrenfest time scale. The predictions of the theory of dynamical localization have been observed in experiments with hydrogen and Rydberg atoms in a microwave field and cold atoms in optical lattices. The quantum Chirikov standard map has been experimentally implemented with cold atoms and Bose-Einstein condensates in kicked optical lattices.

The main results of Chirikov, known as X Chirikov Chaos Commandments (see Fig.3), are described in more detail in the Special Volume dedicated to his 70th birthday, published by Physica D (http://dx.doi.org/10.1016/S0167-2789(99)90007-6) (see also arXiv (http://arxiv.org/abs/cond-mat/9903412)).

The influence of Chirikov's ideas on the field of chaos can also be gauged by the abundance of terms of common use, which were originally coined by him: the Kolmogorov-Arnold-Moser (KAM) theory (Ref.4), the Kolmogorov-Sinai entropy (Refs.4,5), the Arnold diffusion (Ref.4), the standard map (Ref.5), the kicked rotator (Ref.6), dynamical localization, the Ehrenfest time (Ref.12). Chirikov was a rare example of a physicist who was able to discuss science with mathematicians and philosophers, and to publish articles in philosophy (Ref.15).

The physical theory of deterministic chaos developed by Boris Chirikov finds applications for the dynamics of solar system, particle dynamics in accelerators, magnetic plasma traps, complex quantum dynamics and various other systems.

Chaotic Stories

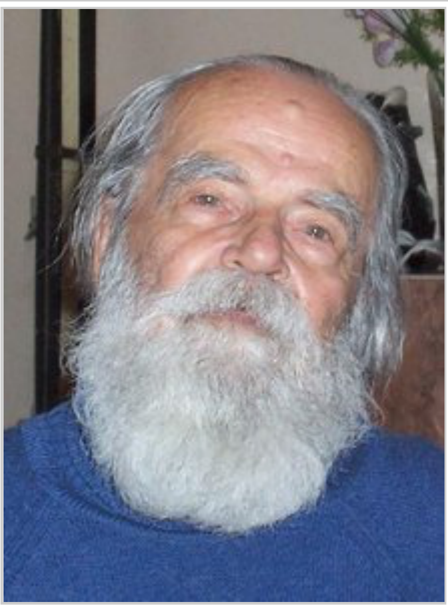
Figure 4: B.V.Chirikov, at home, 10 March 2007

- Chirikov presented his criterion at the seminar in the Kurchatov Institute in 1958. Soon after that he had meeting with Kolmogorov at Kolmogorov's home. After listening the explanations of Chirikov about the criterion Kolmogorov said: "one should be a very brave young man to claim such things!". Indeed, even now a mathematical proof of the criterion is still lacking and there are even known counterexamples of nonlinear systems with a hidden symmetry, where the dynamics remains integrable even in the case of strongly overlapped resonances. A typical example is the Toda lattice. However, such systems with a hidden symmetry are quite rare and specific, while for generic Hamiltonian systems this physical criterion works nicely and determines very well the border for the onset of chaos. The paper with the criterion was published in 1959 since the research on plasma physics became public only after the London agreement in 1958.
- During the Mathematical Congress in Moscow in 1966 Chirikov met Stanislaw Ulam (http://en.wikipedia.org/wiki/Stanislaw_Ulam) , and they spent all days of the conference in hot discussions about chaotic dynamics, nonlinear chains and simple chaotic maps they both were interested in. In fact Ulam came to Moscow via France where he got a Soviet visa. Ulam was due to visit Novosibirsk in the following year (see documents from the archive of Boris Chirikov (http://www.quantware.ups-tlse.fr/chirikov/archive.html)), but all invitations from Novosibirsk remained without any reply: indeed Ulam was too involved in the thermonuclear weapons project, and these letters were stopped by the American side. However, in 1966 the visit of Ulam at the Mathematical Congress in Moscow was completely ignored by the intelligence services of USA and

USSR. Chirikov and Ulam met shortly again in 1979, during the visit of Chirikov to the USA but at that time Ulam was already well protected.

- To give an idea of the importance of chaos research in Siberia, it is useful to quote a passage from the letter of Joe Ford (Georgia Tech) addressed to Chirikov at December 18, 1986 and found in the archive of Boris Chirikov (http://www.quantware.ups-tlse.fr/chirikov/archive.html) : "... your fame has grown and the number of your visits to the West have remained small, you have become something of a "cult" figure. When your name comes up in a crowd of chaos workers (as it inevitably does), the majority who do not know you personally begin to show signs of envy towards those few who do. Stories about Chirikov are told and retold, eventually by people who only claim to know you but do not. I noticed a couple of years ago that even Michael Berry showed signs of succumbing to the Chirikov mania when he somewhat wistfully mentioned to me that he might like to visit Novosibirsk someday. Of course, now he has met you, so he is one of the "in crowd". You have become a legend in your own time by simply not being around!".
- Other stories can be found in the reminiscences of Boris Chirikov (http://www.quantware.ups-tlse.fr/chirikov/reminis.html)

References

(see more at http://www.quantware.ups-tlse.fr/chirikov/publications.html)

1. B.V.Chirikov, "Resonance processes in magnetic traps",At. Energ. 6: 630 (1959) (in Russian; Engl. Transl., J. Nucl. Energy Part C: Plasma Phys. 1: 253 (1960))
2. B.V.Chirikov, G.M.Zaslavsky, "On the mechanism of one-dimensional Fermi acceleration", Dokl. Akad. Nauk SSSR 159: 306 (1964)
3. B.V.Chirikov, F.M.Izrailev, "Statistical properties of a non-linear string", Dokl. Akad. Nauk SSSR 166: 57 (1966)
4. B.V.Chirikov, "Research concerning the theory of nonlinear resonance and stochasticity",Preprint N 267, Institute of Nuclear Physics, Novosibirsk (1969), (Engl. Trans., CERN Trans. 71-40 (1971))
5. B.V.Chirikov, "A universal instability of many-dimensional oscillator systems", Phys. Rep. 52: 263 (1979)
6. G.Casati, B.V.Chirikov, F.M.Izrailev, J.Ford, "Stochastic behavior of a quantum pendulum under a periodic perturbation", Lecture Notes in Physics, Springer, Berlin, 93: 334 (1979)
7. B.V.Chirikov, F.M.Izrailev, D.L.Shepelyansky, "Dynamical stochasticity in classical and quantum mechanics", Sov. Scient. Rev. C 2: 209 (1981) (Section C - Mathematical Physics Reviews, Ed. S.P.Novikov vol.2, Harwood Acad. Publ., Chur, Switzerland (1981))
8. B.V.Chirikov, D.L.Shepelyanskii, "Stochastic oscillations of classical Yang-Mills fields", JETP Lett. 34: 163 (1981)
9. B.V.Chirikov, F.M.Izraelev, "Degeneration of turbulence in simple systems", Physica D 2: 30 (1981)
10. B.V.Chirikov, D.L.Shepelyansky, "Correlation properties of dynamical chaos in Hamiltonian systems", Physica D 13: 395 (1984)

11. G.Casati, B.V.Chirikov, D.L.Shepelyansky, I.Guarneri, ""Relevance of classical chaos in quantum mechanics: the hydrogen atom in a monochromatic field", Phys. Rep. 154: 77 (1987)
12. B.V.Chirikov, F.M.Izrailev, D.L.Shepelyansky, "Quantum chaos: localization vs. ergodicity", Physica D 33: 77 (1988)
13. B.V.Chirikov, V.V.Vecheslavov, "Chaotic dynamics of comet Halley", Astron. Astrophys. 221: 146 (1989)
14. B.V.Chirikov, "Time-dependent quantum systems", in "Chaos and quantum physics", Eds. M-J.Giannoni, A.Voros and J.Zinn-Justin, Les Houches, Session LII (1989), Elsvier Sci. Publ. B.V. p.443 (1991)
15. B.V.Chirikov, "Natural laws and human prediction", in "Law and prediction in the light of chaos research", Eds. P.Weingartner, G.Schurz, Springer, Berlin, Lecture Notes in Physics 473: 10 (1996)

Internal references

- Paul M.B. Vitanyi (2007) Andrey Nikolaevich Kolmogorov. Scholarpedia, 2(2):2798.
- John W. Milnor (2006) Attractor. Scholarpedia, 1(11):1815.
- Boris Chirikov and Dima Shepelyansky (2008) Chirikov standard map. Scholarpedia, 3(3):3550.
- James Meiss (2007) Dynamical systems. Scholarpedia, 2(2):1629.
- James Meiss (2007) Hamiltonian systems. Scholarpedia, 2(8):1943.
- Martin Gutzwiller (2007) Quantum chaos. Scholarpedia, 2(12):3146.
- David H. Terman and Eugene M. Izhikevich (2008) State space. Scholarpedia, 3(3):1924.

External links

- website dedicated to Boris Chirikov (http://www.quantware.ups-tlse.fr/chirikov/)
- Boris Chirikov at Wikipedia (http://en.wikipedia.org/w/index.php?title=Boris_Chirikov)
- J.Bellissard, D.L.Shepelyanski, "Boris Chirikov, a pioneer in classical and quantum chaos", Annales de l'institut Henri Poincare (A) Physique theorique 68: 379 (1998) (http://www.numdam.org/numdam-bin/fitem?id=AIHPA_1998__68_4_379_0) (and also here (http://www.quantware.ups-tlse.fr/dima/myrefs/myp03.pdf))
- Special Volume dedicated to 70th of Boris Chirikov: Physica D 131:1-4 vii (1999) (http://www.quantware.ups-tlse.fr/dima/myrefs/myp04c.pdf) and arXiv (http://arxiv.org /abs/cond-mat/9903412)
- Article at CERN Courier (2003) (http://cerncourier.com/cws/article/cern/28869/3)
- Obituary at CERN Courier (http://cerncourier.com/cws/article/cern/33810/3) ,Obituary at

Physics Today, June (2008) (http://ptonline.aip.org/journals/doc/PHTOAD-ft/vol_61/iss_6/67_1.shtml)

- Articles in Russian: Nauka v Sibiri (1988) (http://www.quantware.ups-tlse.fr/chirikov/aboutchirikov/naukasibiri1988.pdf) ,Nauka v Sibiri (1998) (http://www-sbras.nsc.ru/HBC/article.phtml?nid=182&id=6) , Uspekhi Fiz. Nauk (1998) (http://ufn.ru/ru/articles/1998/7/j/) ,Vestnik Akademii Nauk (2005) (http://www.quantware.ups-tlse.fr/chirikov/aboutchirikov/mukhin2005.pdf) ,Nauka v Sibiri (2008) (http://www.nsc.ru/HBC/article.phtml?nid=451&id=25) , UFN (2008) (http://ufn.ru/ru/articles/2008/4/l/)
- Reminiscences of Boris Chirikov (http://www.scholarpedia.org/wiki/images/ftp/chirikov2008s.pdf)

See also internal links

Chirikov standard map, Chirikov criterion, Hamiltonian systems, Mapping, Chaos, Kolmogorov-Arnold-Moser Theory, Kolmogorov-Sinai entropy, Aubry-Mather theory, Quantum chaos

Dima Shepelyansky (2008) Boris Valerianovich Chirikov. Scholarpedia, 3(10):6628, (go to the first approved version)
Created: 19 February 2008, reviewed: 22 October 2008, accepted: 25 October 2008
Invited by: Eugene M. Izhikevich
Action editor: James Meiss
Retrieved from "http://www.scholarpedia.org/article/Boris_Valerianovich_Chirikov"
Categories: Mappings | Biography | History of physics | Quantum Chaos

- ISSN 1941-6016