Chaos at Fifty Four in 2013

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In contrast to the claim of Motter and Campbell on Chaos at Fifty, done at arXiv:1306.5777, it is pointed out that in 2013 we are at Chaos Fifty Four, if to count correctly and to remember about pioneering results of Boris Chirikov obtained in 1959.

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The recent Feature Article entitled *Chaos at Fifty* by Motter and Campbell [1] highlights Lorenz's discovery in 1963, which, as they say, "gave birth to a field that still thrives". Without any doubts Edward Lorentz did an outstanding work but the real history of scientific research of chaos does not allow to attribute the birth event to Fifty in 2013.

The physical birth of chaos happened before that in Hamiltonian systems with a few degrees of freedom. In fact, the Chirikov resonance-overlap criterion [3] was introduced in 1959 by Boris Chirikov and successfully applied by him to explain the confinement border for plasma in open mirror traps observed in experiments at the Kurchatov Institute at Moscow. This was the very first physical and analytical criterion for the onset of chaotic motion in deterministic Hamiltonian systems. Its validity in generic Hamiltonian systems has been confirmed in numerous numerical simulations performed by Chirikov and his collaborators for the Fermi acceleration model [4], the Fermi-Pasta-Ulam problem [5], dynamical maps and various physical systems [6, 7], [8]. An example of resonance overlap with integrable islands and chaotic component of motion is shown in Fig. 1 for the Chirikov standard map. These figures are take from the review papers of Chirikov [6, 8]. The phase space of the same map at similar parameters is shown in Fig. 4 of [1] with computer facilities being much more advanced compared to those of 1969 and 1979. Unfortunately, the authors of [1] forget to say that the main properties and universal features of this map had been discovered by Chirikov (read more about the Chirikov standard map at [9]). This map describes the confinement border for plasma in open mirror traps explained in [3].

The recognition of pioneering results of Chirikov is well established among experts of chaos community. In contrast to [1], this is the most quoted author in the fundamental book on regular and chaotic dynamics [10]. It should be also pointed out that there are also many fundamental mathematical and physical papers on dynamical chaos, done in USSR-Russia and Western Europe, which remained ignored in [1]. These works, done at the early stage of chaos research, include the Kolmodorov-Arnold-Moser theory of integrability [11, 12],[13], chaos in Anosov systems [14] and Sinai billiards [15], Henon-Heiles model [16], Kolmogorov-Sinai entropy [17] and others.

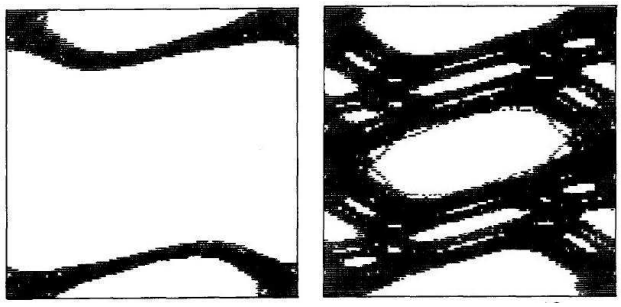

FIG. 1: Poincaré section of the phase space (x, y) of the Chirikov standard map at chaos parameter $K = 0.96$ (left), $K = 1.13$ (right); chaos regions covered by one trajectory are shown in black (after [6, 8]). The map has the form $\bar{y} = y + K \sin x, \bar{x} = x + \bar{y}(mod 2\pi)$, where bars mark new variable values after one map iteration.

A more balanced description of history of dynamical chaos can be find in [10, 17, 18]. Articles about scientific research of Boris Chirikov are available at [20, 21], [22, 23],[24] and at the website dedicated to him [25].

[1] A.E. Motter, D.K. Campbell, *Chaos at Fifty*, arXiv:1306.5777 [nlin.CD] (2013) (published at Physics Today **66(5)**, 27-33 (2013)

[2] E.N. Lorenz, J. Atmos. Sci. **20**, 130 (1963)

[3] B.V.Chirikov, Atomic. Energ. **6** 630 (1959) (in Russian; Engl. Transl., J. Nucl. Energy Part C: Plasma Phys. **1**, 253 (1960))

[4] G.M Zaslavskii, B.V. Chirikov, Dokl. Akad. Nauk SSSR **159** 306 (1964) [in Russian; Engl. Trans. Soviet Physics - Doklady, **9**, 989 (1964)]

[5] F.M.Izrailev, B.V.Chirikov, Dokl. Akad. Nauk SSSR **159**, 306 (1966) [in Russian; Engl. Trans. Soviet Physics - Doklady **11(1)**, 30 (1966)]

[6] B.V.Chirikov, *Research concerning the theory of nonlinear resonance and stochasticity*, Preprint N 267, Institute of Nuclear Physics, Novosibirsk (1969), (in Russian; Engl. Trans., CERN Trans. 71-40 (1971)

[7] G.M Zaslavskii, B.V. Chirikov, Uspekhi Fiz. Nauk **105(1)**, 3 (1971) [in Russian; Engl. Trans. Sov. Phys. Uspekhi-USSR **14**, 549 (1972)

[8] B.V.Chirikov, Phys. Rep. **52**, 263 (1979)

[9] B.Chirikov, D.Shepelyansky, *Chirikov standard map*, Scholarpedia **3(3)**, 3550 (2008)

[10] A.J.Lichtenberg, M.A.Lieberman, *Regular and chaotic dynamics*, Springer, Berlin (1992)

[11] A.N.Kolmogorov, Dokl. Akad. Nauk SSSR **98**, 527 (1954) [in Russian]

[12] V.I.Arnold, Usp. Mat. Nauk **18(6)**, 91 (1963)

[13] J. Moser, Nachr. Akad. Wiss., Gttingen, Math. Phys. **KI(1)**, 1 (1962)

[14] D.V. Anosov, DokI. Akad. Nauk SSSR **145**, 707 (1962); **ibid. 151**, 1250 (1963) [in Russian]

[15] Ya.G. Sinai, Dokl. Akad. Nauk SSSR **153**, 1261 (1963) [in Russian]

[16] M. Henon, C. Heiles, Astron. J. **69**, 73 (1964)

[17] Y.Sinai, *Kolmogorov-Sinai entropy*, Scholarpedia **4(3)**, 2034 (2009)

[18] Ph.Holmes, *History of dynamical systems*, Scholarpedia, **2(5)**, 1843 (2007)

[19] D.Shepelyansky, *Chirikov criterion*, Scholarpedia **4(9)**, 8567 (2009)

[20] J.Bellissard, D.L.Shepelyanski, *Boris Chirikov, a pioneer in classical and quantum chaos*, Ann. Inst. Henri Poincare (Special Issue dedicated to Boris Chirikov) **68(4)**, 379 (1998)

[21] J.Belissard, O.Bohigas, G.Casati and D.L.Shepelyansky, *A pioneer of chaos*, Physica D **131**, ix (1999) (see also arXiv:cond-mat/9903412v1).

[22] F.Izrailev, A.Lichtenberg, D.Shepelyansky, *Boris Valerianovich Chirikov (obituary)*, Physics Today June, p.67 (2008)

[23] D.Shepelyansky, *Boris Valerianovich Chirikov* , Scholarpedia **3(10)**, 6628 (2008)

[24] D.Shepelyansky, *Chirikov criterion*, Scholarpedia **4(9)**, 8567 (2009)

[25] Website dedicated to Boris Chirikov: http://www.quantware.ups-tlse.fr/chirikov/