

Elena Surovyatkina

Chaos in the Atmosphere:
how to deal with the issue?

What is Chaos?



what is chaos?



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cha·os

/ˈkɑː.əs/

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noun

complete disorder and confusion.
"snow caused chaos in the region"

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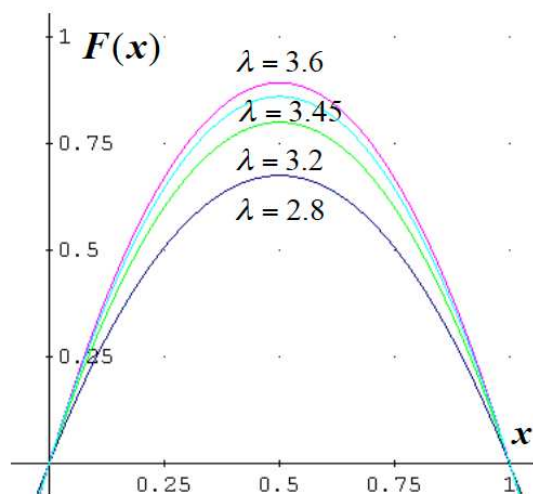
- **PHYSICS**

behavior so unpredictable as to appear random, owing to great sensitivity to small changes in conditions.

- the formless matter supposed to have existed before the creation of the universe.

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Translations and more definitions



LOGISTIC MAP

$$x_{n+1} = \lambda x_n (1 - x_n)$$

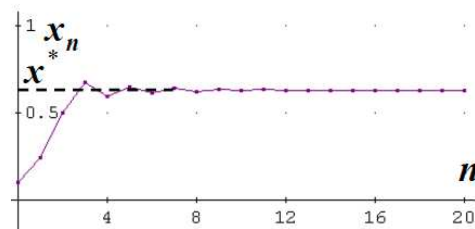


limit-cycle

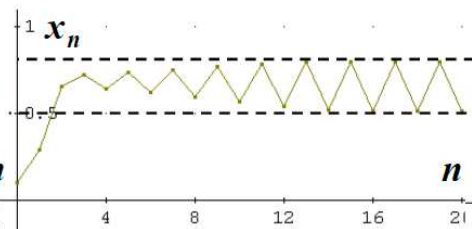
2-cycle

4-cycle

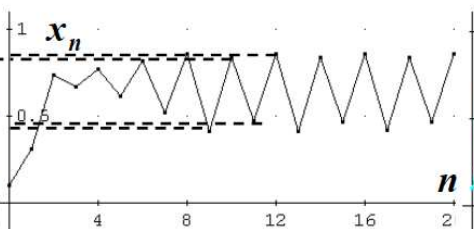
CHAOS



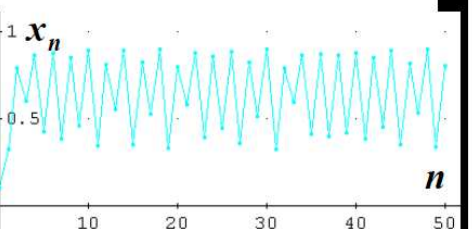
$\lambda = 2.8$



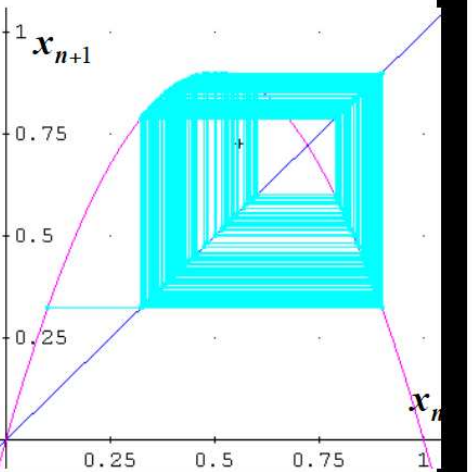
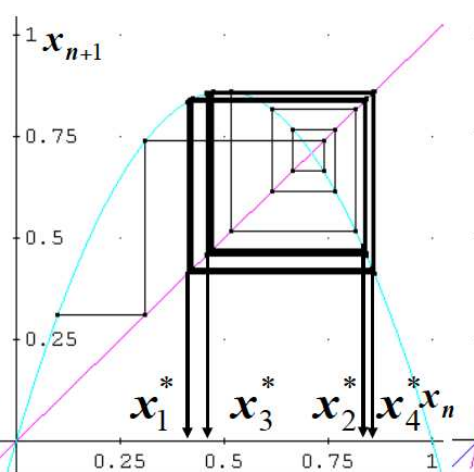
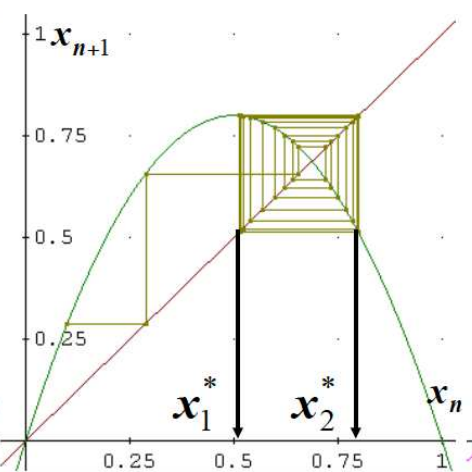
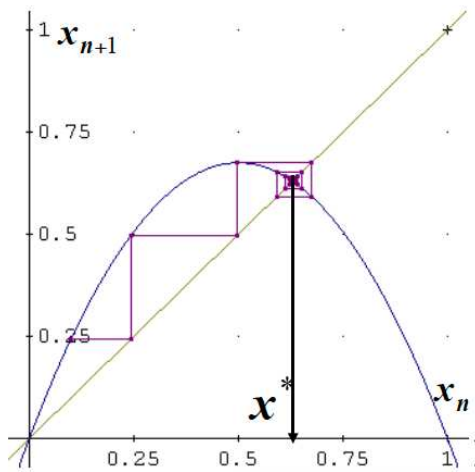
$\lambda = 3.2$



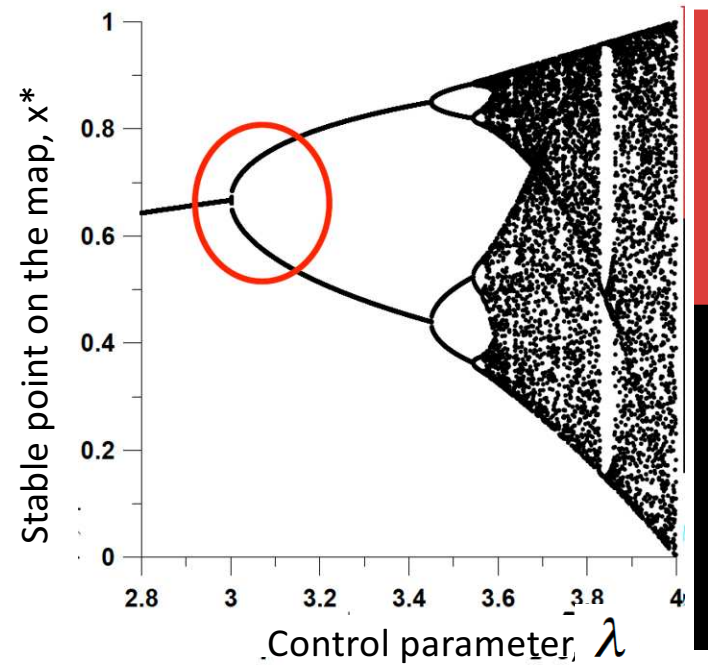
$\lambda = 3.45$



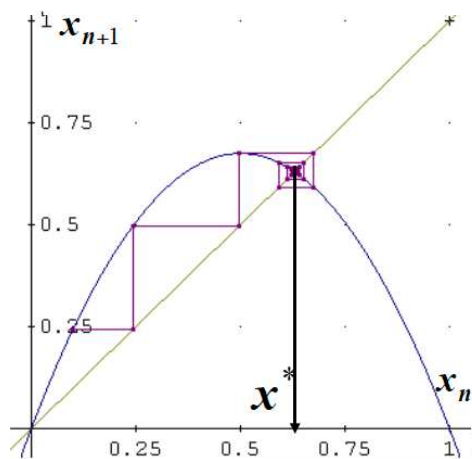
$\lambda = 3.6$



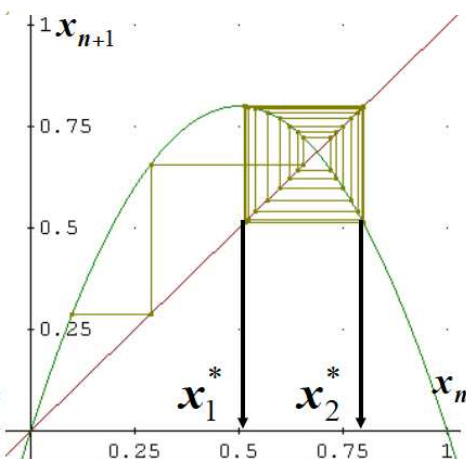
$$x_{n+1} = \lambda x_n (1 - x_n)$$



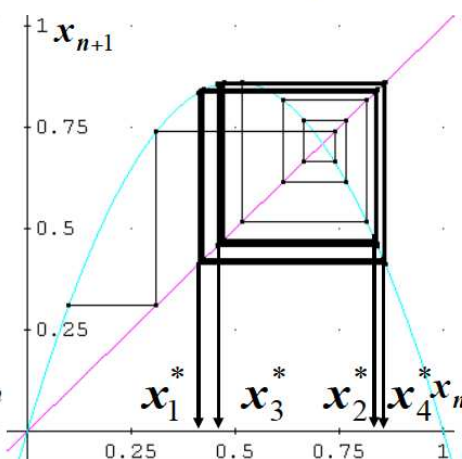
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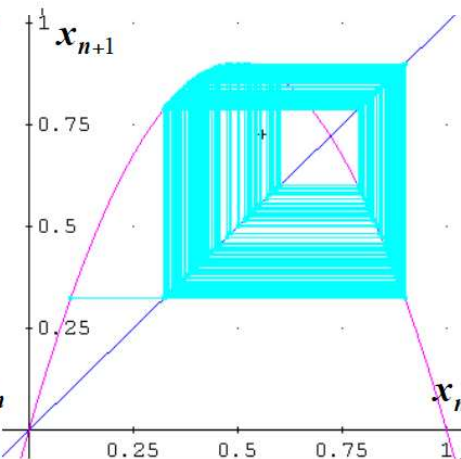
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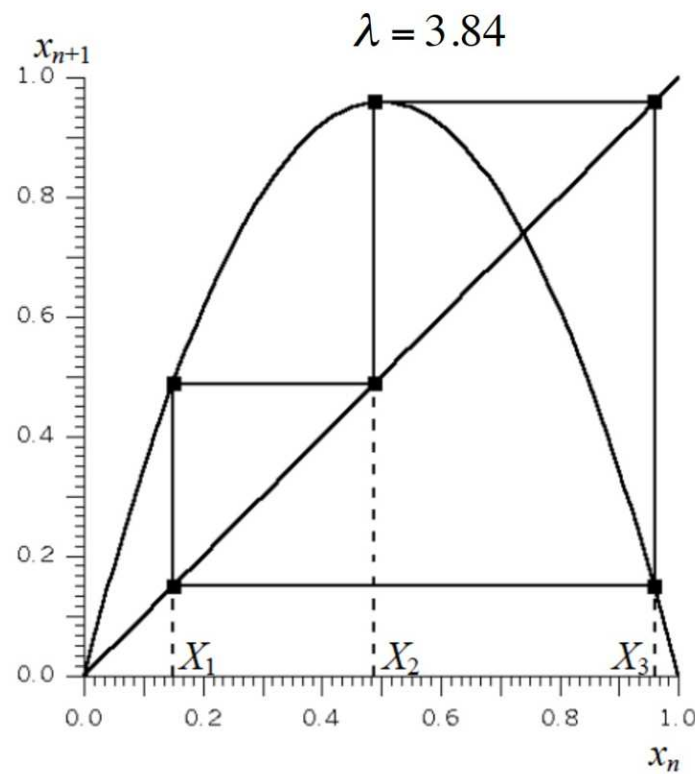
$\lambda = 3.45$



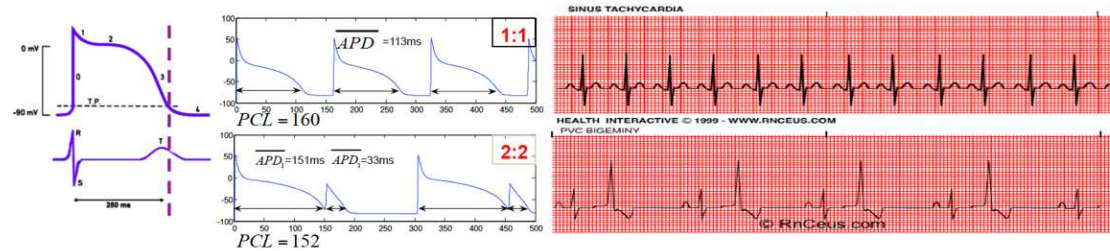
$\lambda = 3.6$



ATTRACTOR OF PERIOD THREE

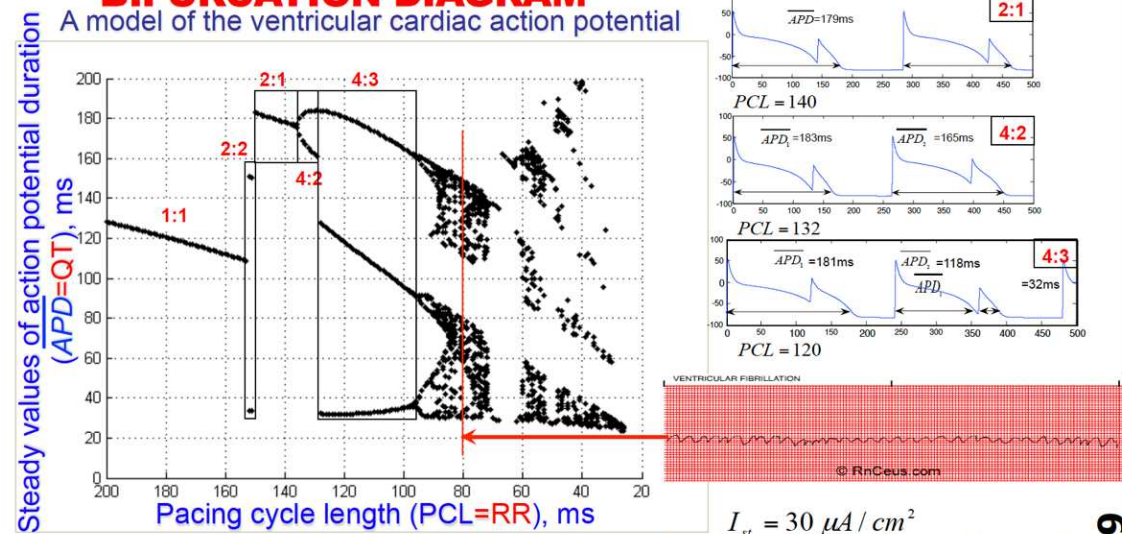


$$x_{n+1} = \lambda x_n (1 - x_n)$$



BIFURCATION DIAGRAM

A model of the ventricular cardiac action potential



E. Surovyatkina. Bifurcations and Multistability in Cardiac Cells. Springer/Wien 2012 .



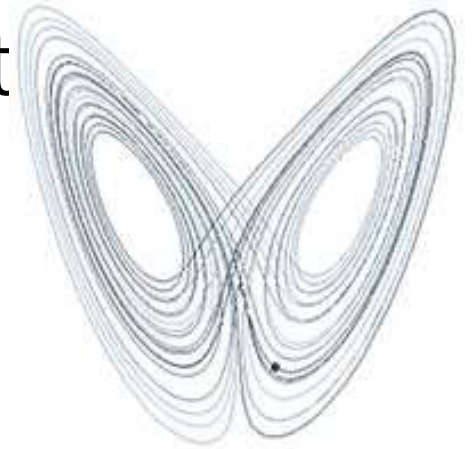
Edward Norton Lorenz
May 23, 1917 – April 16, 2008

Butterfly effect

$$\frac{dx}{dt} = \sigma(y - x),$$

$$\frac{dy}{dt} = x(\rho - z) - y,$$

$$\frac{dz}{dt} = xy - \beta z.$$



The equations relate the properties of a two-dimensional fluid layer uniformly warmed from below and cooled from above.

The equations describe the rate of change of three quantities with respect to time:

- x is proportional to the rate of convection,
- y to the horizontal temperature variation, and
- z to the vertical temperature variation.

The constants σ , ρ , and β are parameters proportional to the Prandtl number, Rayleigh number, and certain physical dimensions of the layer itself.

The idea that small causes may have large effects in weather was earlier recognized by French mathematician and engineer Henri Poincaré (1854-1912). Lorenz's work placed the concept of instability of the Earth's atmosphere onto a quantitative base and linked the concept of instability to the properties of large classes of dynamic systems which are undergoing nonlinear dynamics and deterministic chaos.

Useful links:

- MONSOON FORECAST WEB-PAGE

<https://www.pik-potsdam.de/en/output/infodesk/forecasting-indian-monsoon/welcome-to-the-pik-monsoon-page-1>

- NCEP/NCAR reanalysis data

<https://downloads.psl.noaa.gov/Datasets/ncep.reanalysis/Dailies/pressure/>