Optical chaos based on a laser diode with positive feedback

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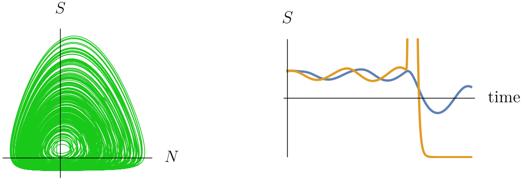
Definition of dynamic chaos and applications

Map[1] f is **chaotic**, if

- periodic orbits are dense everywhere;
- orbits are mixed;
- f sensitive to the initial conditions.



$\Rightarrow$;

[1] W. Hirsch, S. Smale, Introduction to Chaos.

The concept of a semiconductor laser

To start the laser idea we need to obtain:

- Solution of the Schrödinger equation in a semiconductor medium for the wavefunction of an electron;
- Induced polarization for distribution of holes and electrons in a semiconductor;
- Interaction of electrons in a semiconductor with an wave equation and outer electric field.

Electronic states in a semiconductor

We will need the Schrödinger equation:

$$H_{\text{crystal}}\Psi_n(\boldsymbol{r}) = \left[\frac{\boldsymbol{p}^2}{2m_0} + U_p(\boldsymbol{r})\right]\Psi_n(\boldsymbol{r}),$$

where $\boldsymbol{p} = -i\hbar\nabla$ is the momentum operator, m_0 is the free electron mass, $U_p(\boldsymbol{r})$ is th periodic potential of the bulk semiconductor.

The solution is the Bloch function:

$$\Psi_{n,\boldsymbol{k}}(\boldsymbol{r}) = u_{n,\boldsymbol{k}}(\boldsymbol{r})\frac{1}{\sqrt{V}}e^{i\boldsymbol{k}\cdot\boldsymbol{r}}.$$