
Katb. HochschulGemeinde
Delayed feedback control of the system with hyperbolic attractor
Methods of stabilization of chaotic systems
Theory of hyperbolic attractor
Evolution of hyperbolic attractors
Pyragas Method

Система уравнений содержащая гиперболический аттрактор с запаздыванием

$$\dot{x}_1 = \omega y_1 + (1 - a_2 + \tfrac{1}{2} a_1 - \tfrac{1}{50} a_1^2) x_1 + \varepsilon x_2 y_2,$$

$$\dot{y}_1 = -\omega x_1 + (1 - a_2 + \tfrac{1}{2} a_1 - \tfrac{1}{50} a_1^2) y_1 + D_{t,t-\tau},$$

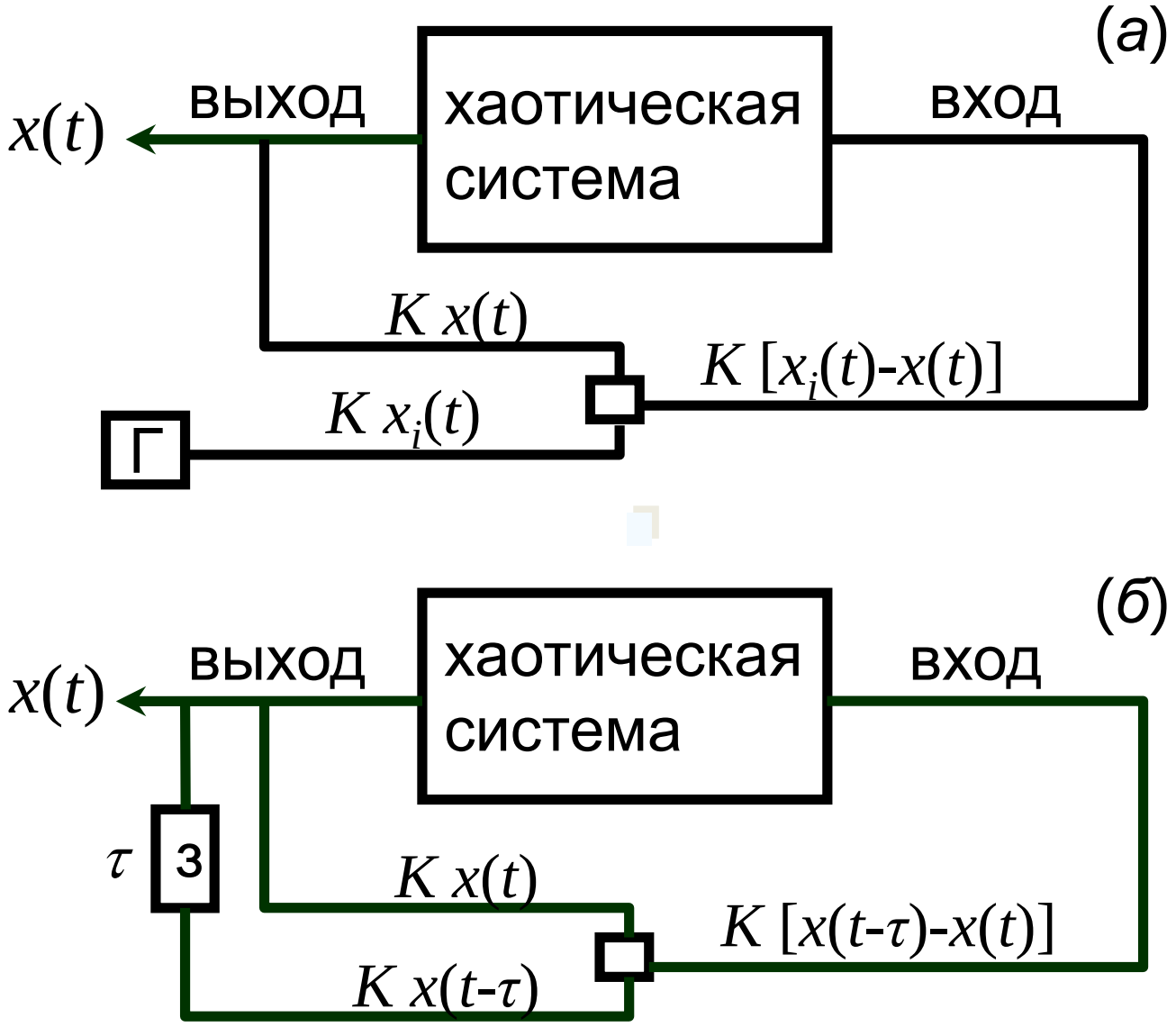
$$\dot{x}_2 = \omega y_2 + (a_1 - 1) x_2 + \varepsilon x_1,$$

$$\dot{y}_2 = -\omega x_2 + (a_1 - 1) y_2^{x_{1,t}},$$

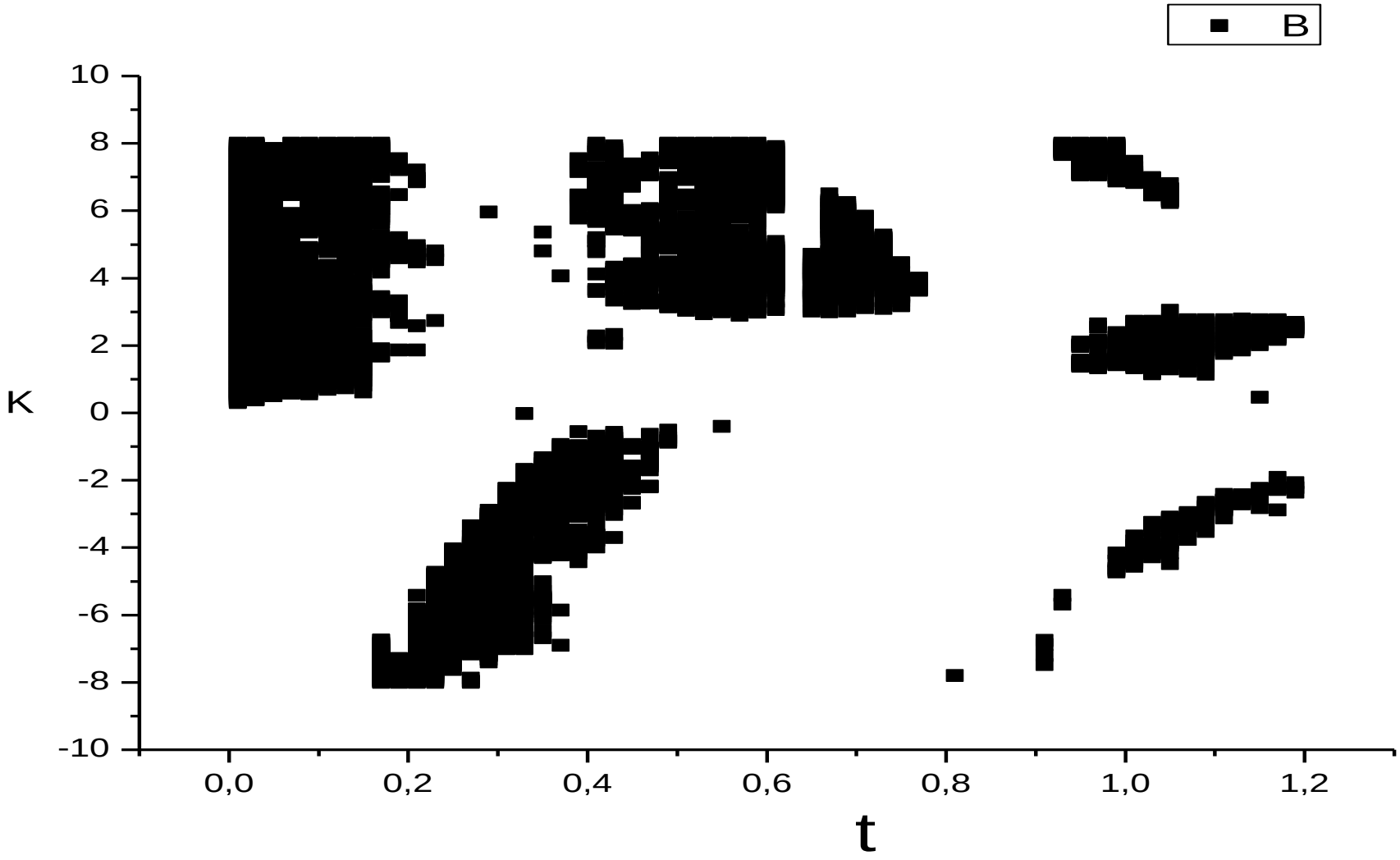
$$a_1 = x_1^2 + y_1^2, a_2 = x_2^2 + y_2^2.$$

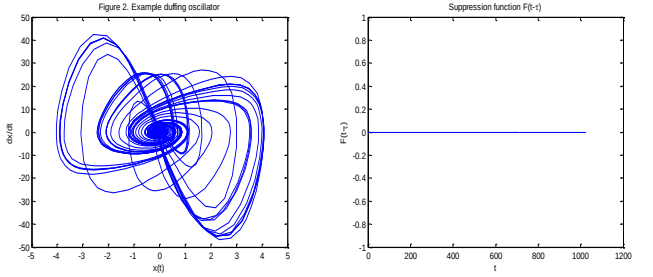
$$D_{t,t-\tau} = K(x_{1,t-\tau} - x_{1,t})$$

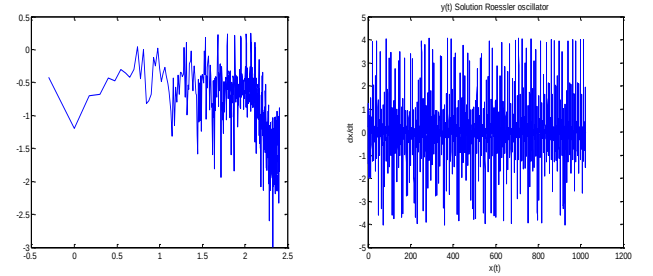
Методы стабилизации хаотических систем



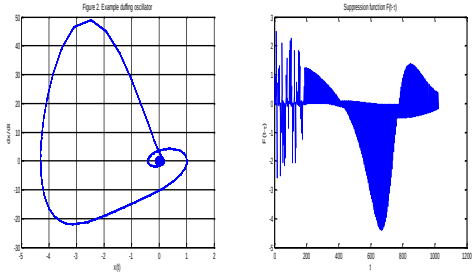
Область стабильности
K/τ

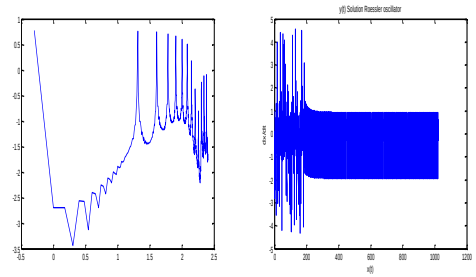




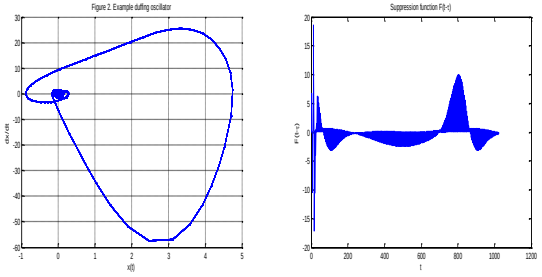


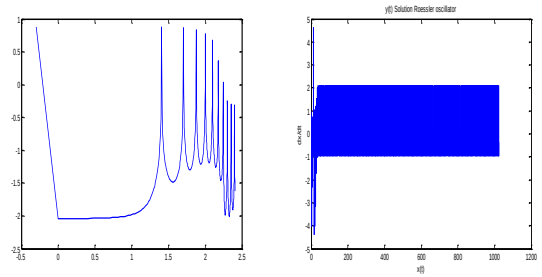
K=0



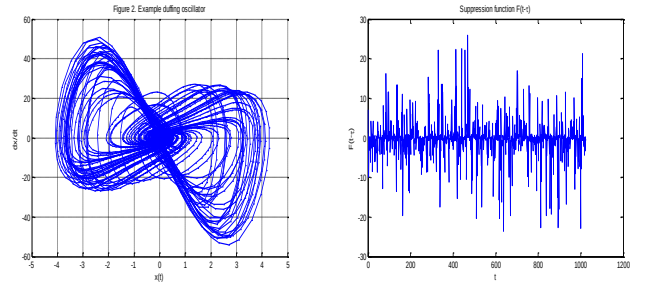


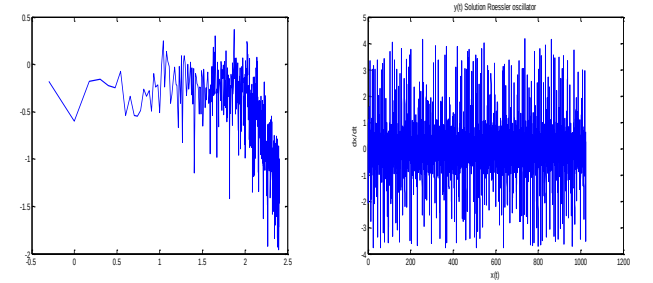
K=1π , τ =0.06



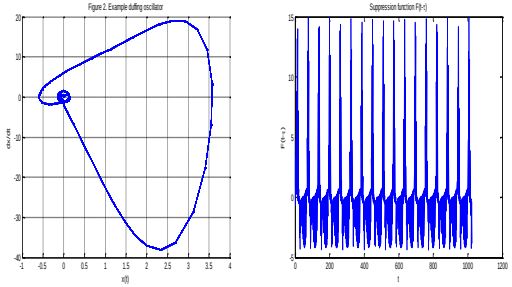


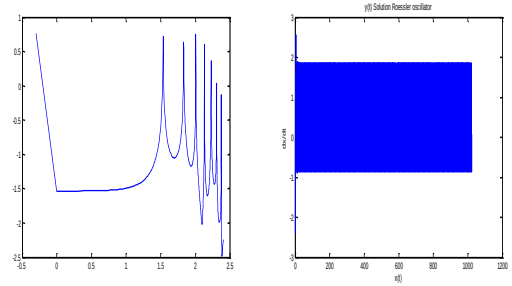
K=2π , τ =0.06



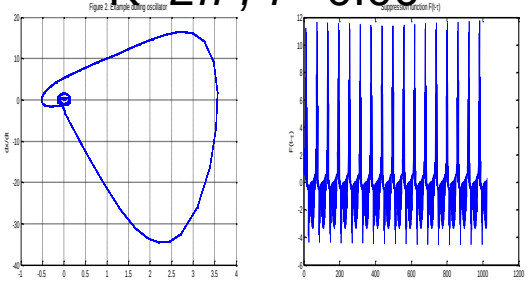


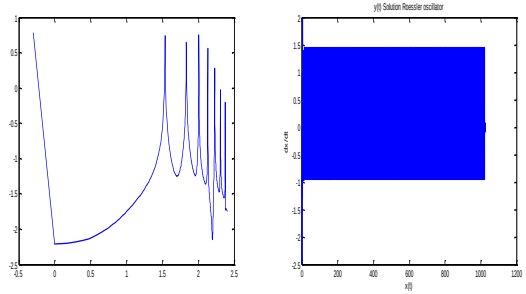
K=2π , τ =0.21





K=-2π , τ =0.20





K=-π , τ =0.40

Система уравнений содержащая гиперболический аттрактор с запаздыванием

$$\dot{x}_1 = \omega y_1 + (1 - a_2 + \tfrac{1}{2} a_1 - \tfrac{1}{50} a_1^2) x_1 + \varepsilon x_2 y_2,$$

$$\dot{y}_1 = -\omega x_1 + (1 - a_2 + \tfrac{1}{2} a_1 - \tfrac{1}{50} a_1^2) y_1 + D_{t,t-\tau},$$

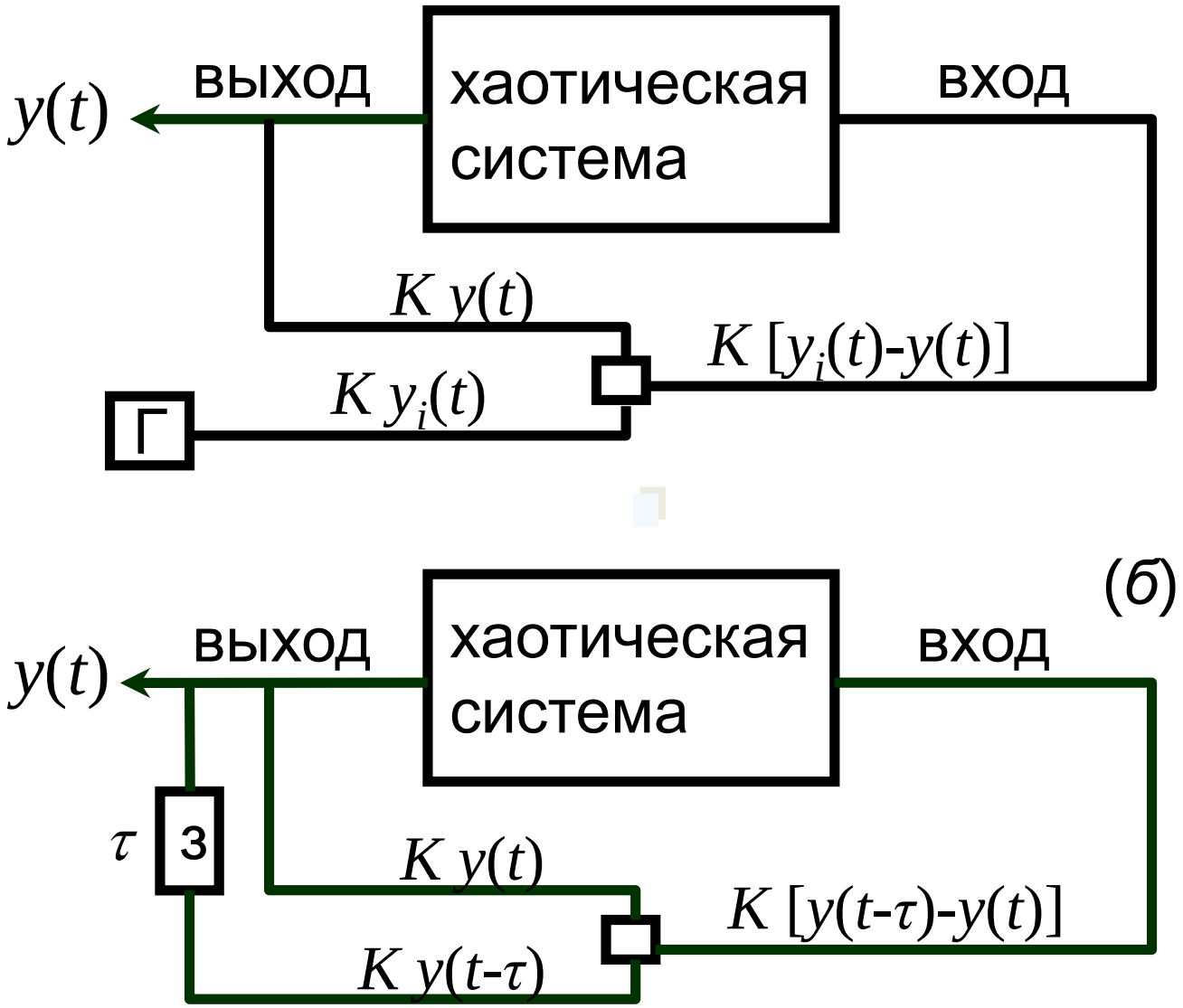
$$\dot{x}_2 = \omega y_2 + (a_1 - 1) x_2 + \varepsilon x_1,$$

$$\dot{y}_2 = -\omega x_2 + (a_1 - 1) y_2,$$

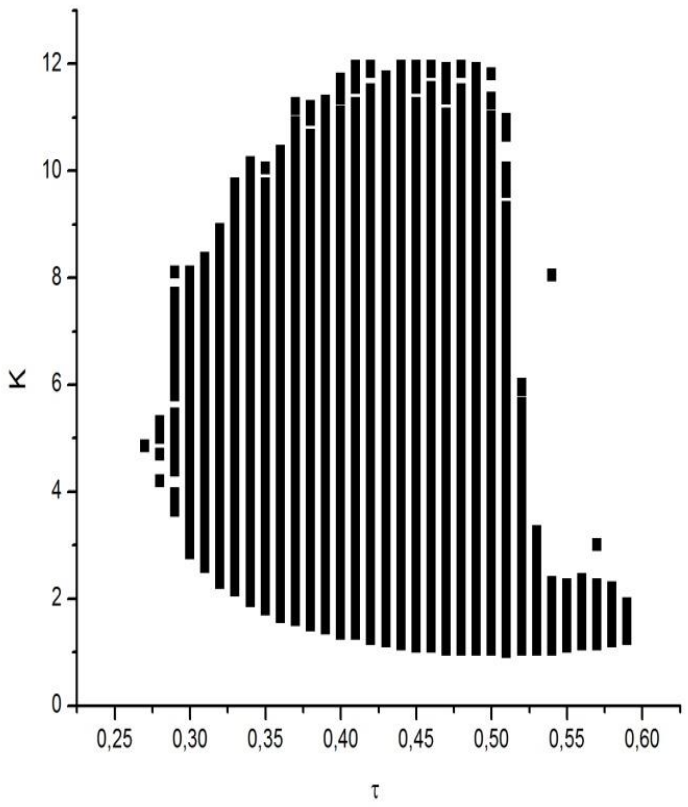
$$a_1 = x_1^2 + y_1^2, a_2 = x_2^2 + y_2^2.$$

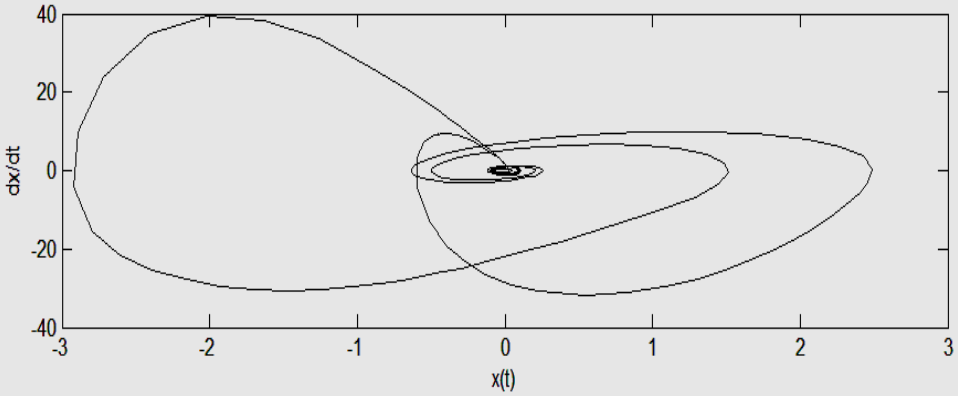
$$D_{t,t-\tau} = K(y_{1,t-\tau} - y_{1,t})$$

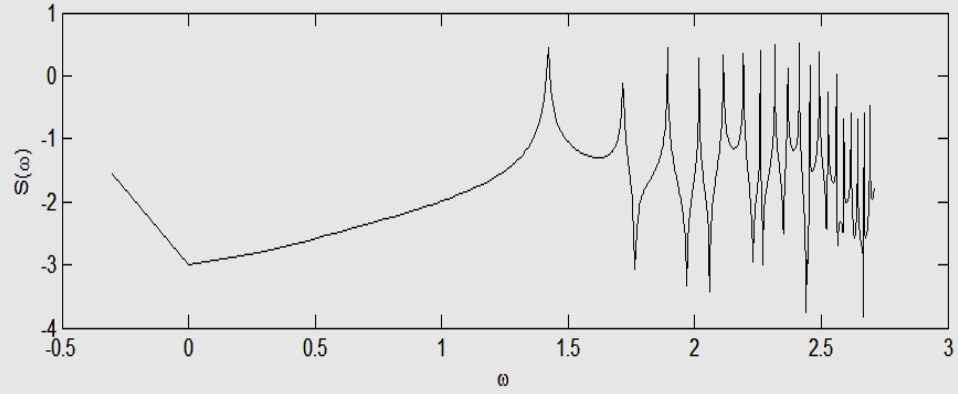
Методы стабилизации хаотических систем



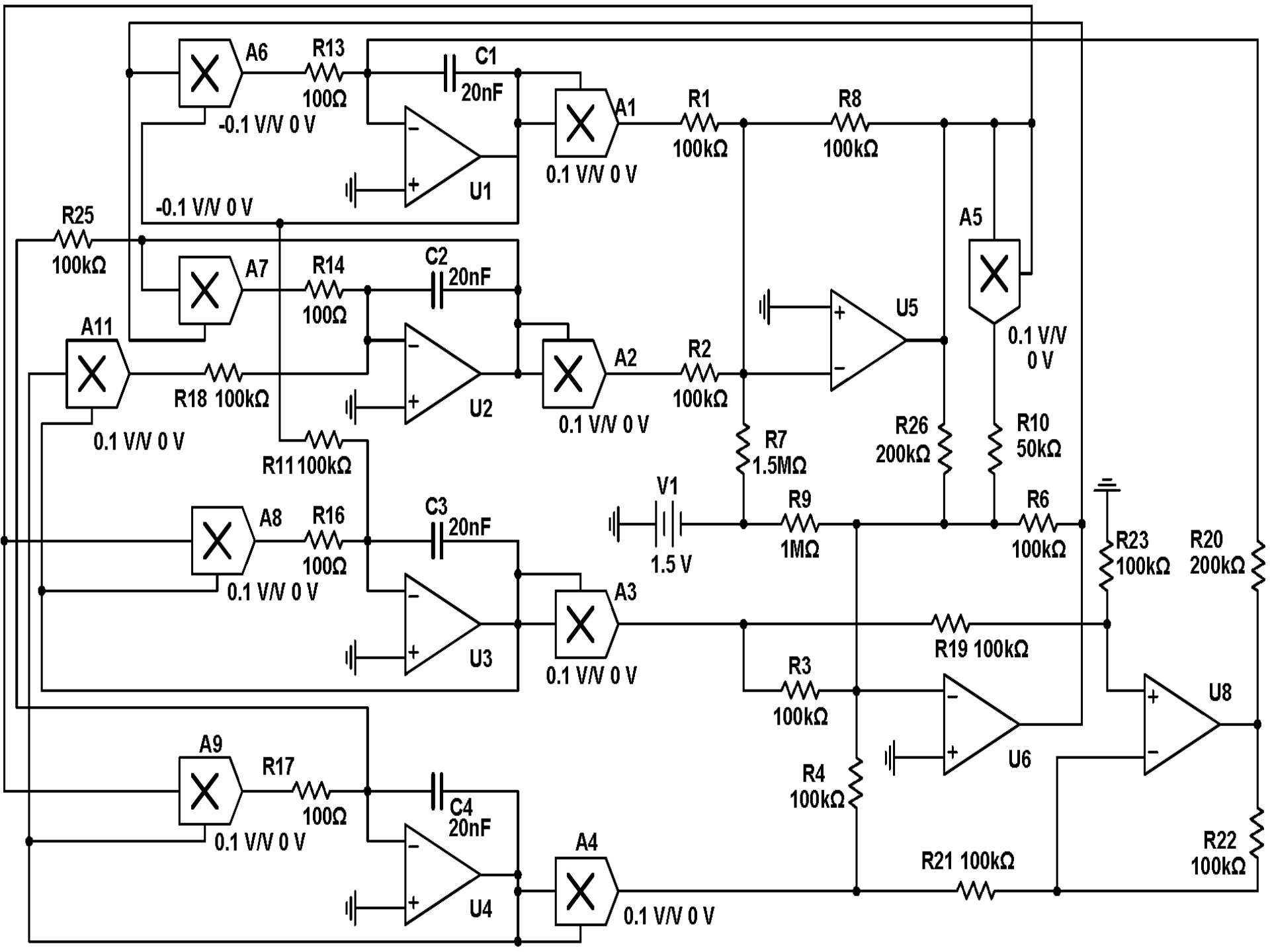
Область стабильности K/τ







$$K = -4.5,\ \tau = 0.4$$


A6
R13
100Ω
C1
20nF
-0.1 V/V 0 V
U1
A1
R1
100kΩ
R8
100kΩ
0.1 V/V 0 V
-0.1 V/V 0 V
R25
100kΩ
A7
R14
100Ω
C2
20nF
A5
U5
0.1 V/V
0 V
A11
R18 100kΩ
U2
A2
R2
100kΩ
0.1 V/V 0 V
0.1 V/V 0 V
R11 100kΩ
R7
1.5MΩ
R26
200kΩ
R10
50kΩ
V1
1.5 V
R9
1MΩ
R6
100kΩ
A8
R16
100Ω
C3
20nF
0.1 V/V 0 V
U3
A3
0.1 V/V 0 V
R23
100kΩ
R20
200kΩ
R19 100kΩ
R3
100kΩ
U8
U6
A9
R17
100Ω
C4
20nF
0.1 V/V 0 V
R4
100kΩ
U4
A4
R21 100kΩ
R22
100kΩ
0.1 V/V 0 V

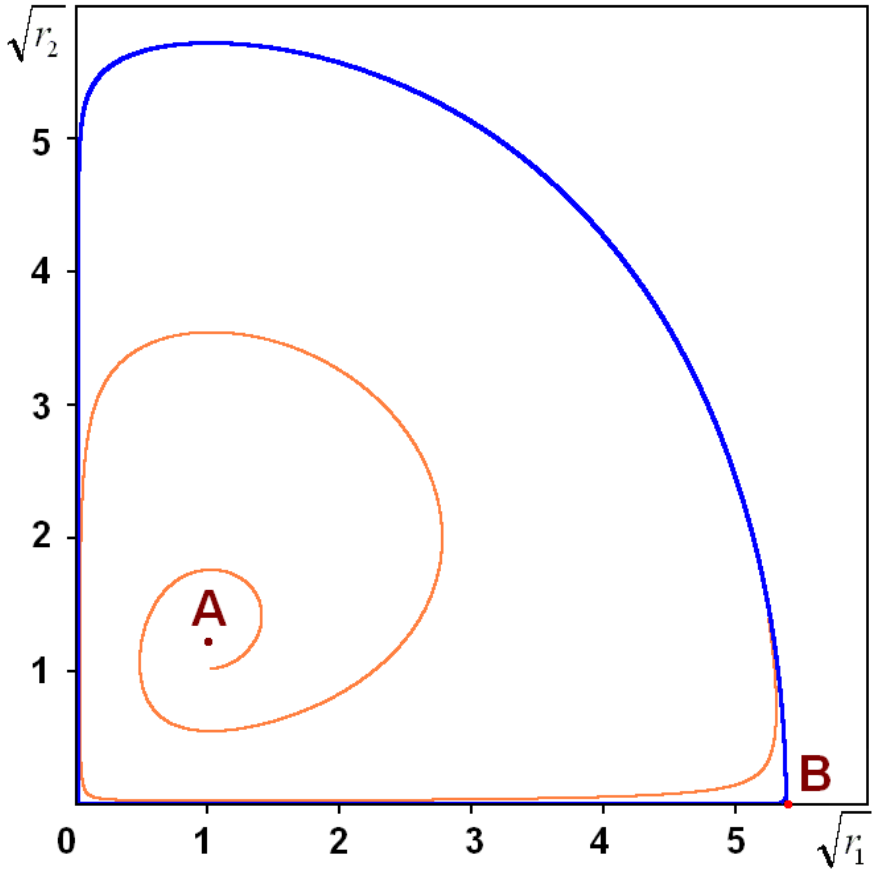
система «хищник – жертва» вида

$$\dot{r}_1 = 2\left[1 - r_2 + \tfrac{1}{2} r_1 - \tfrac{1}{50}(1 - r_1)^2\right] r_1,$$

$$\dot{r}_2 = 2(r_1 - 1) r_2.$$

Введем переменные

$$r_2 = u^2 + v^2 \quad r_1 = x^2 + y^2$$



Автономная система с аттрактором Смейла – Вильямса

$$\frac{dx}{dt} = \mu_1(x, y, u, v)x - \tfrac{1}{2}\varepsilon_1(u^2 - v^2),$$

$$\frac{dy}{dt} = \mu_1(x, y, u, v)y - \varepsilon_1 uv + D_{t,t-\tau},$$

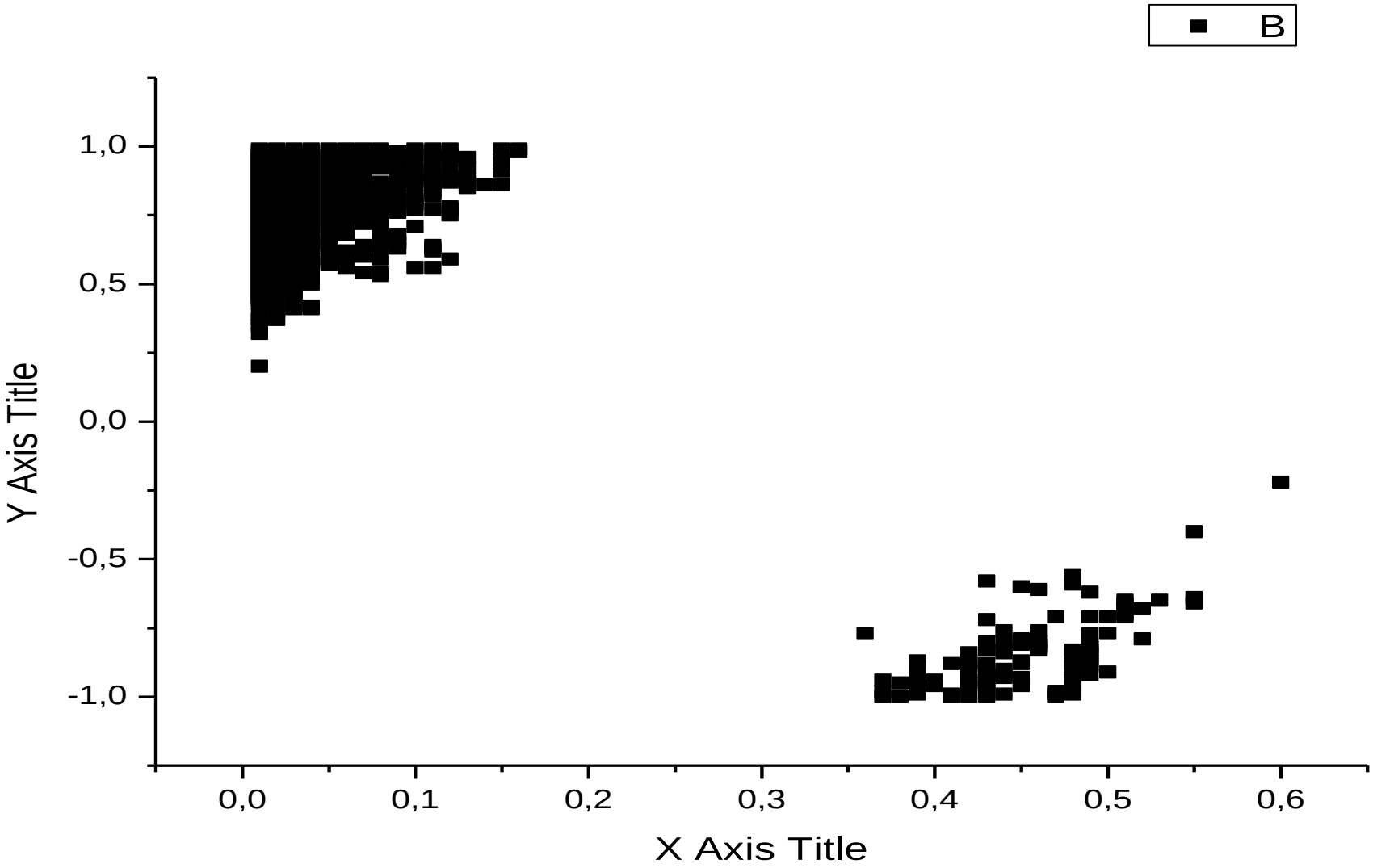
$$\frac{du}{dt} = \mu_2(x, y)u - \varepsilon_2 x,$$

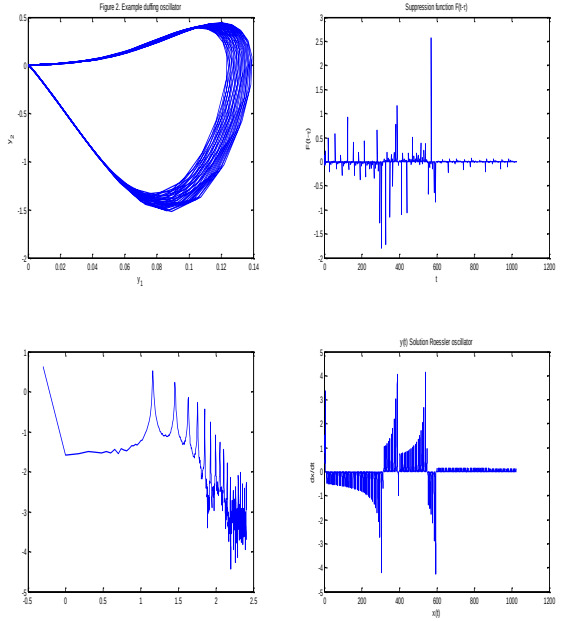
$$\frac{dv}{dt} = \mu_2(x, y)v - \varepsilon_2 y,$$

$$\mu_1 = 1 - r_2 + \tfrac{1}{2}r_1 - \tfrac{1}{50}(1 - r_1)^2,\ \mu_2 = r_1 - 1,\ r_1 = x^2 + y^2,\ r_2 = u^2 + v^2.$$

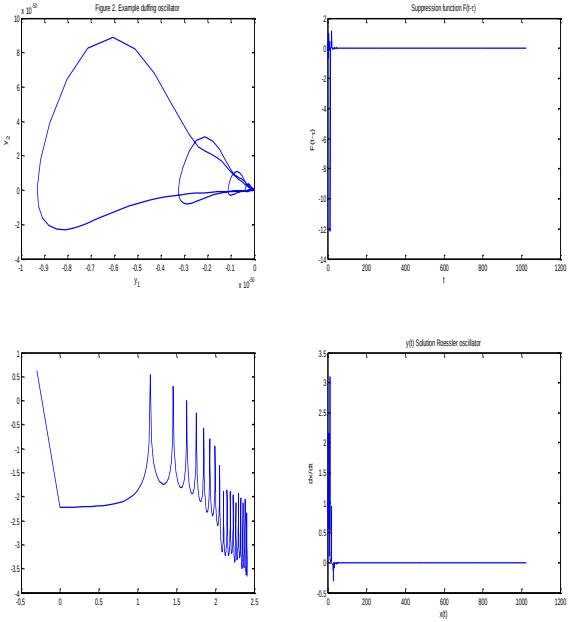
$$\varepsilon_1 = 0.01,\ \varepsilon_2 = 0.1 \qquad D_{t,t-\tau} = K(y_{t-\tau} - y_t)$$

Область стабильности
K/т

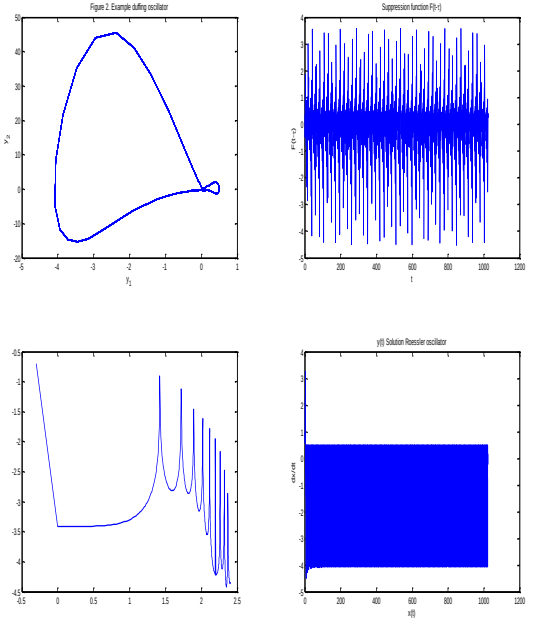




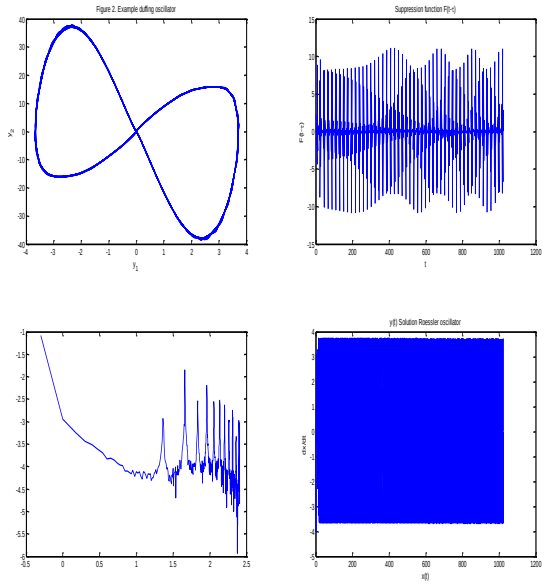
K=4.0; tau=0.04



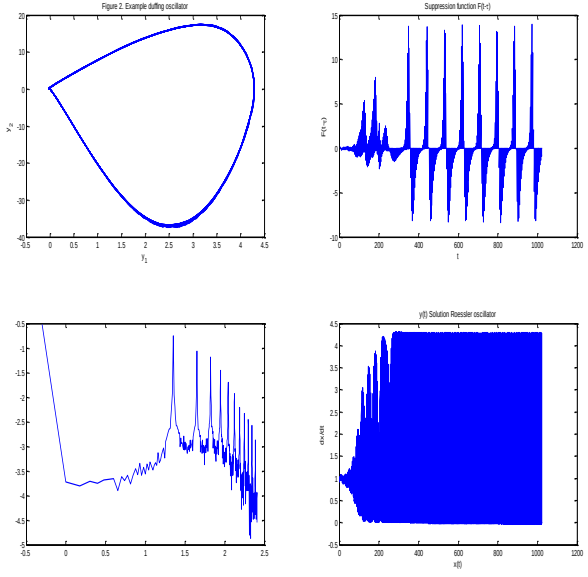
K=8.0; tau=0.08



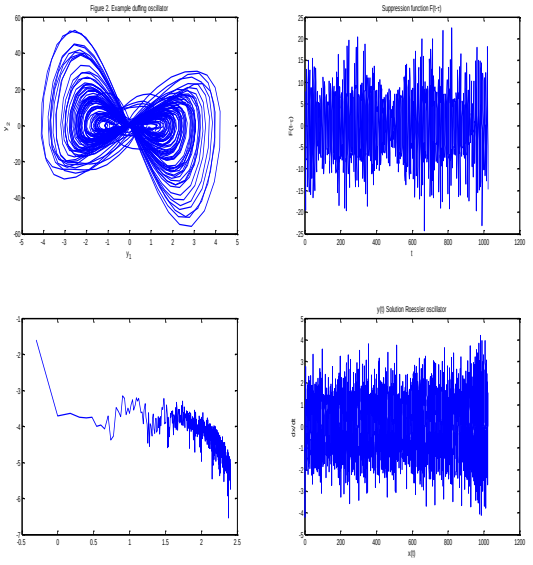
K=-1.0; tau=0.8



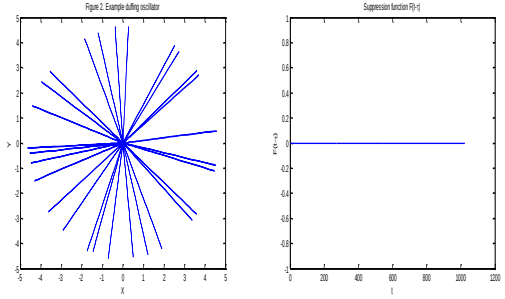
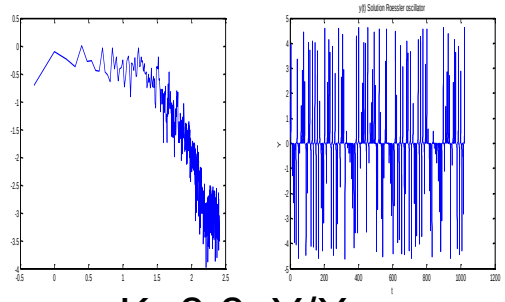
K=-2.0 ;tau=2.0;



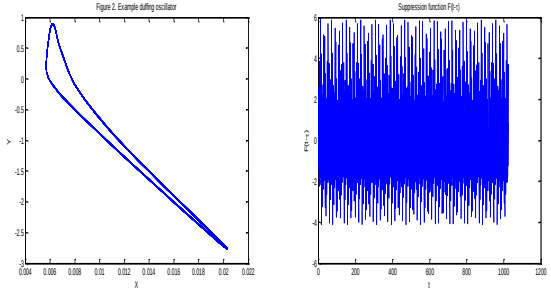
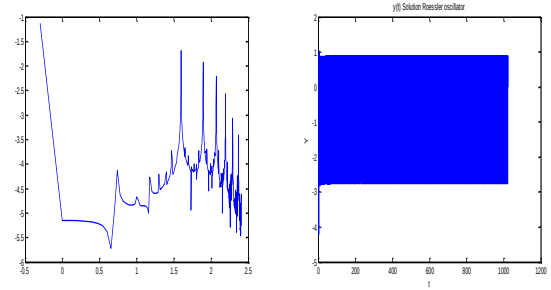
K=4.0; tau=4.0



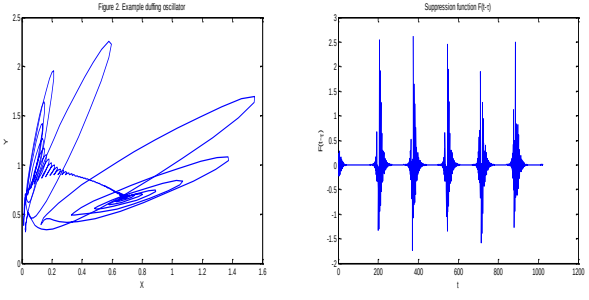
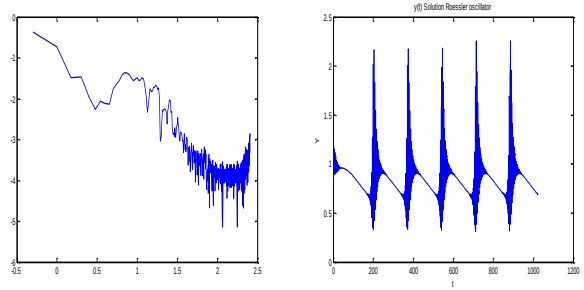
K=-4.0; tau=4.0

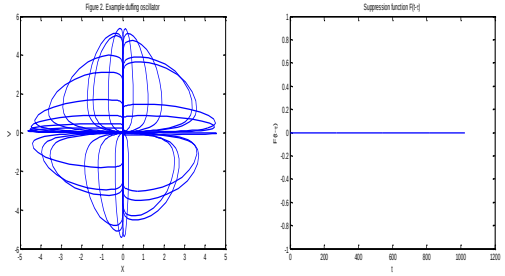
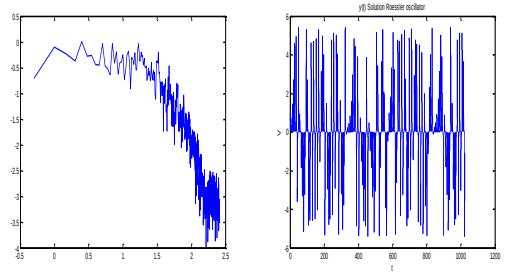
K=0.0 Y/X

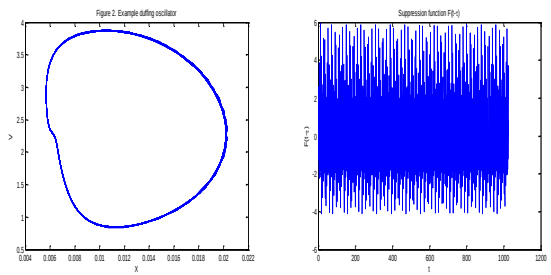
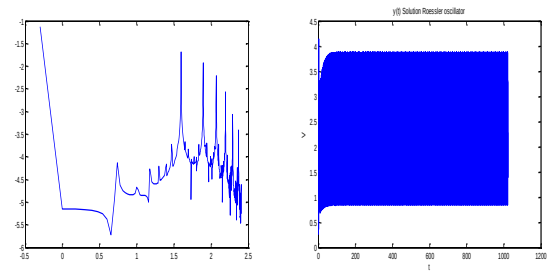
K=-1.70 tau=0.70

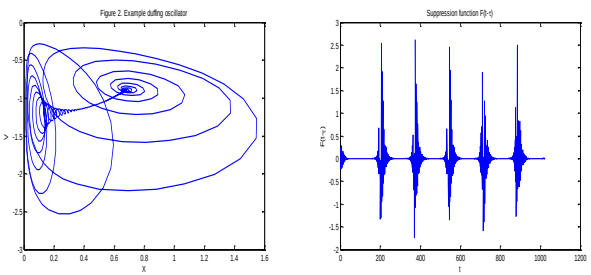
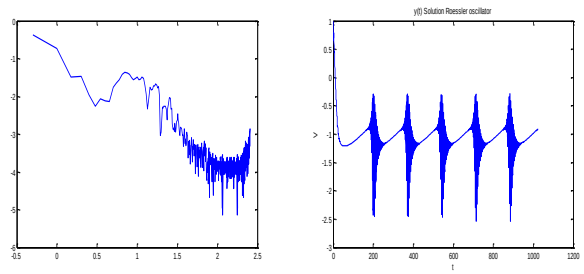
K=1.70 tau=0.70

K=0.0 V/X

K=-1.70 tau=0.70

K=1.70 tau=0.70

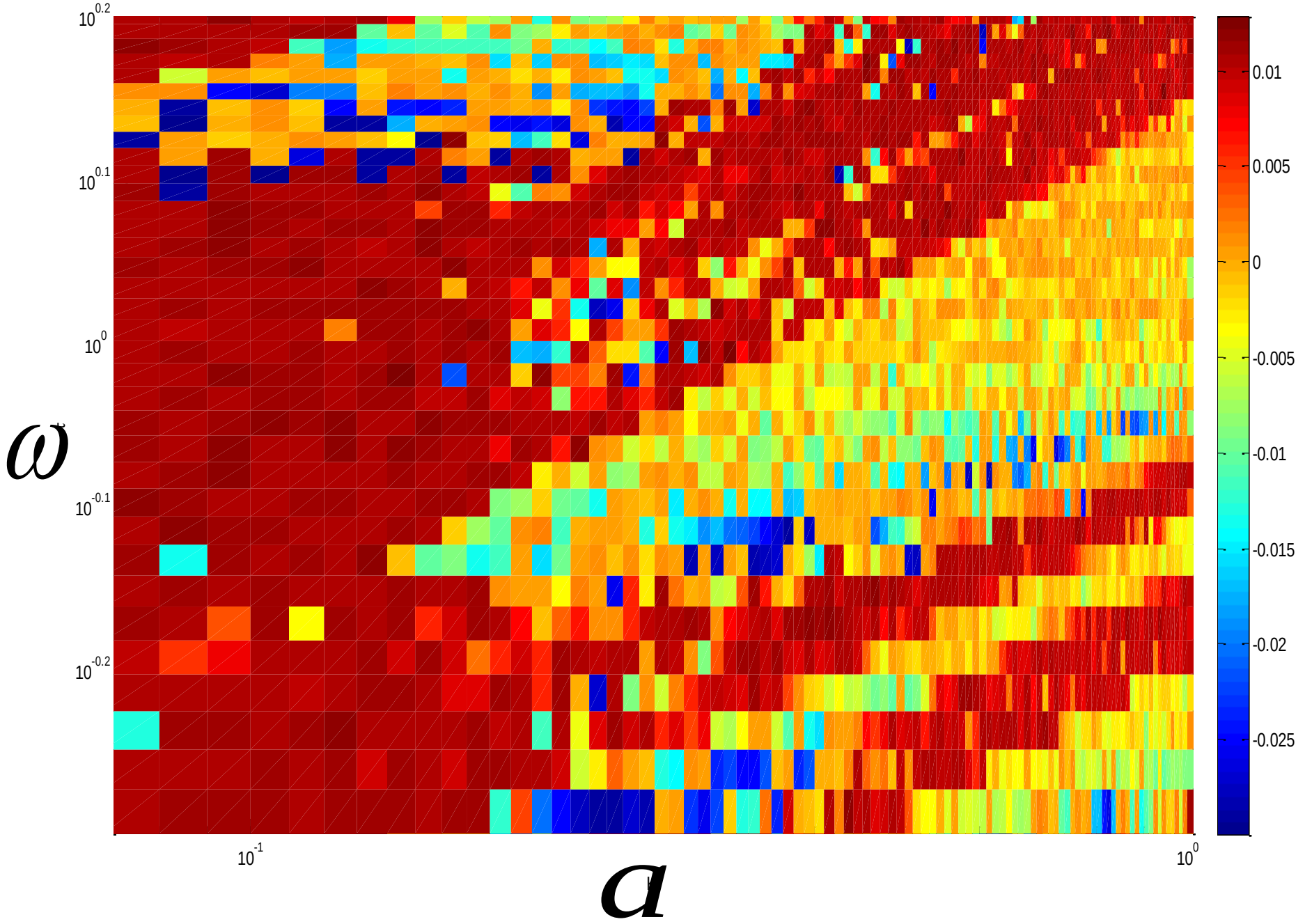
$$\frac{dx}{dt} = \mu_1(x, y, u, v)x - \tfrac{1}{2}\varepsilon_1(u^2 - v^2),$$

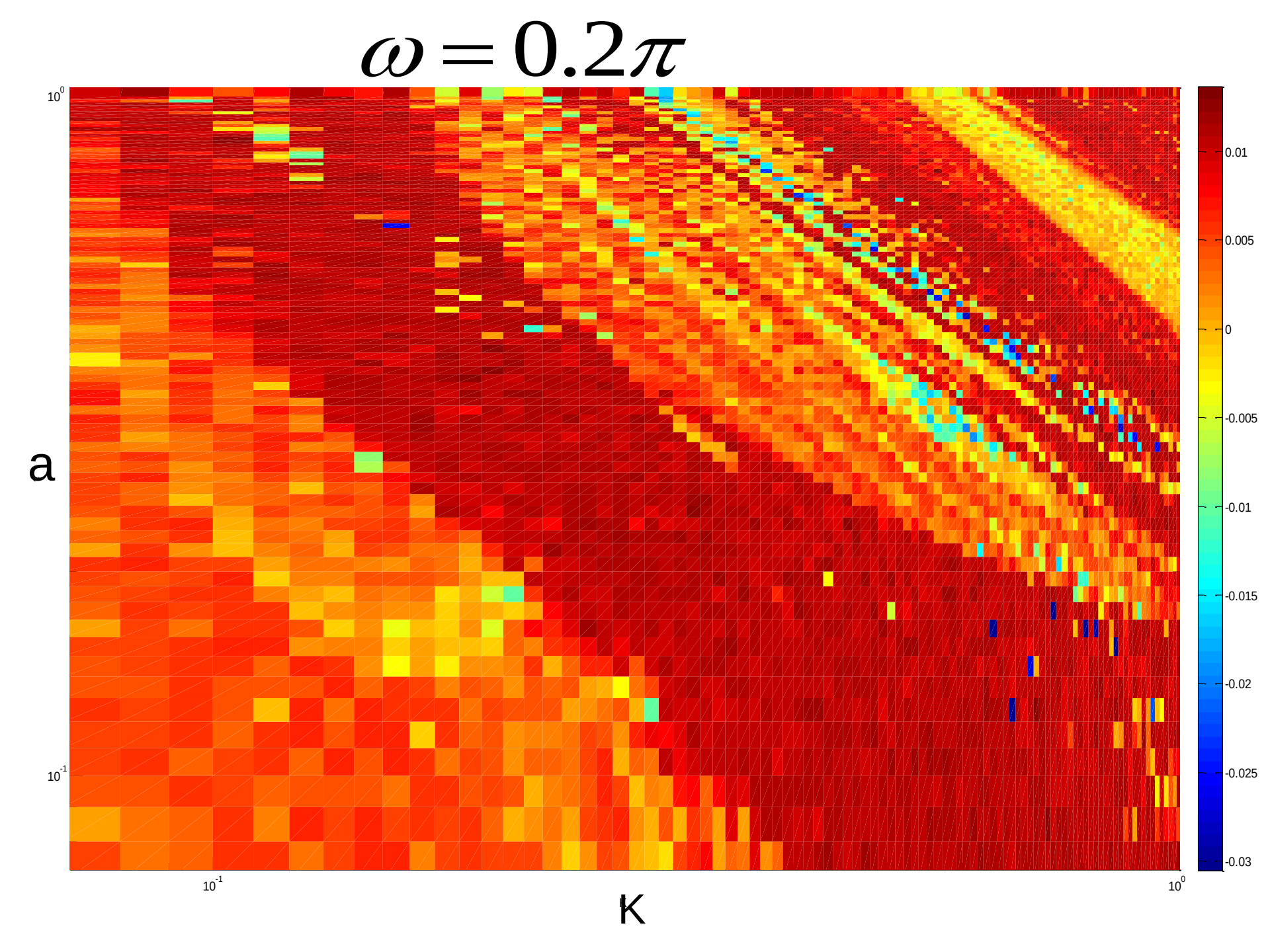
$$\frac{dy}{dt} = \mu_1(x, y, u, v)y - \varepsilon_1 uv + D_{t,a\sin\omega t},$$

$$\frac{du}{dt} = \mu_2(x, y)u - \varepsilon_2 x,$$

$$\frac{dv}{dt} = \mu_2(x, y)v - \varepsilon_2 y,$$

$$D_{t,a\sin\omega t} = K(a\sin\omega t - y)$$


K=1
$10^{0.2}$
$10^{0.1}$
10^{0}
$10^{-0.1}$
$10^{-0.2}$
ω
10^{-1}
10^{0}
a
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025

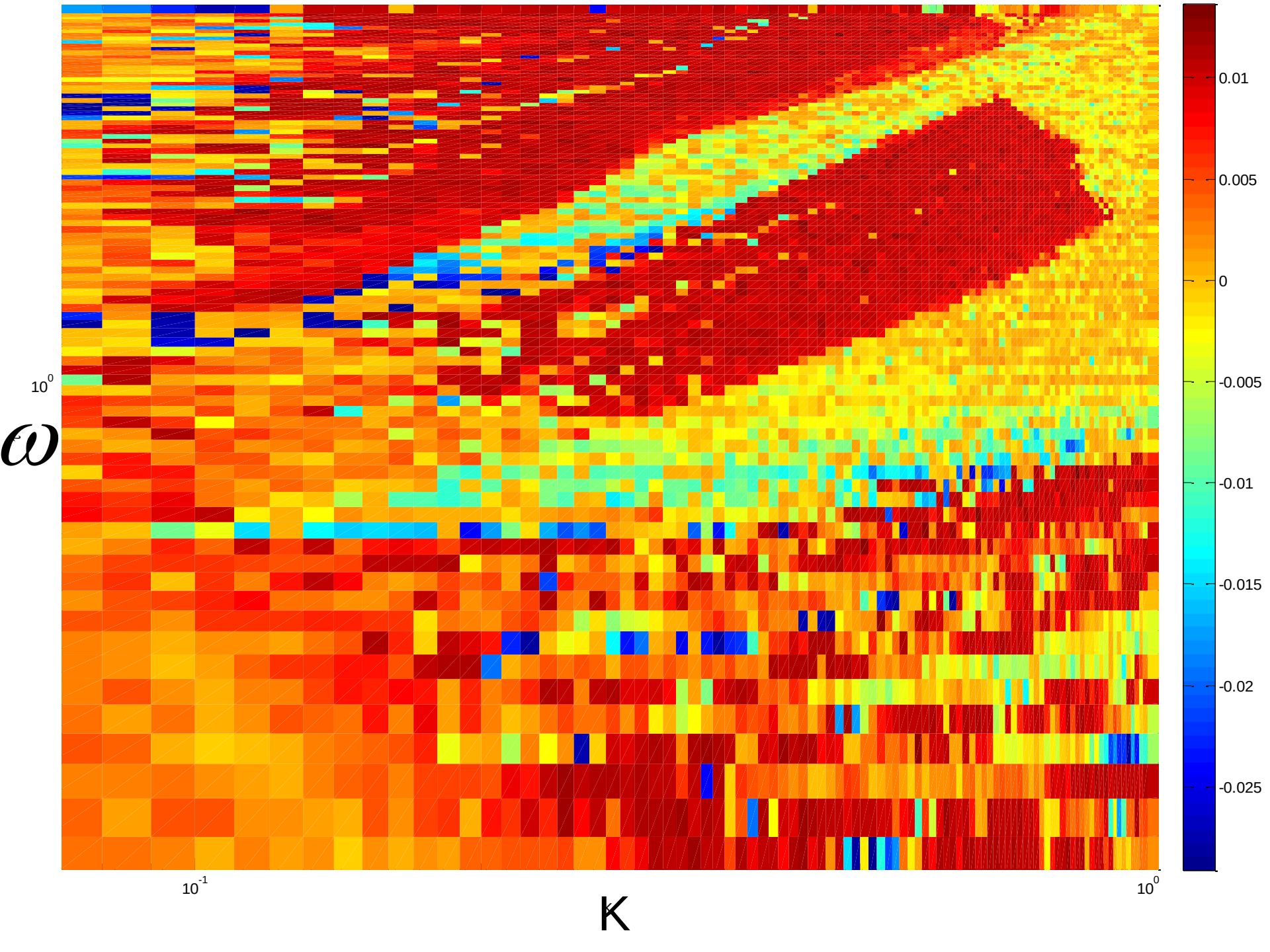

$\omega = 0.2\pi$
10^0
10^{-1}
a
10^{-1}
10^0
K
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
-0.03

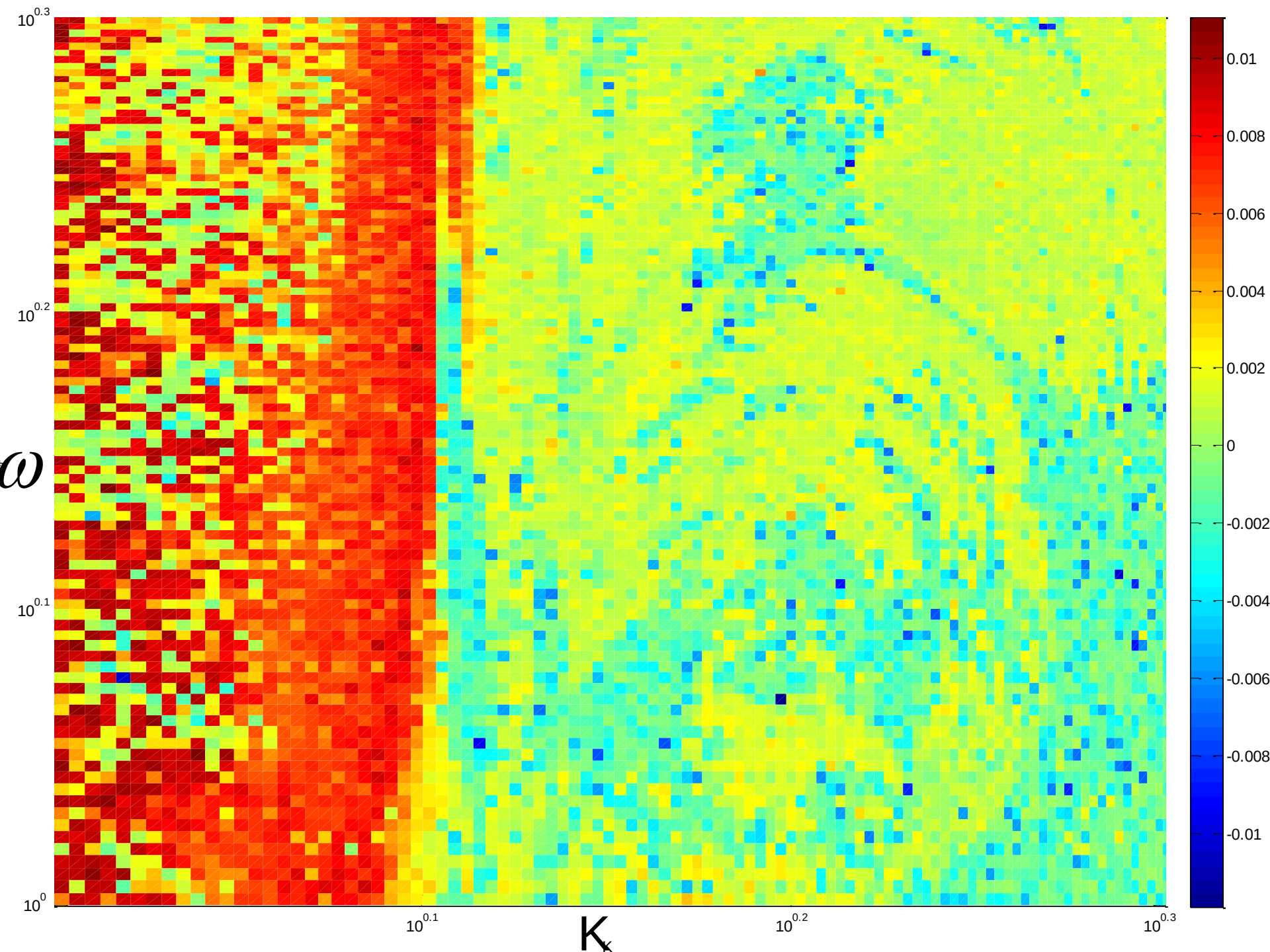
$$\frac{dx}{dt} = \mu_1(x, y, u, v)x - \tfrac{1}{2}\varepsilon_1(u^2 - v^2),$$

$$\frac{dy}{dt} = \mu_1(x, y, u, v)y - \varepsilon_1 uv + K\omega\cos\omega t,$$

$$\frac{du}{dt} = \mu_2(x, y)u - \varepsilon_2 x,$$

$$\frac{dv}{dt} = \mu_2(x, y)v - \varepsilon_2 y,$$


0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
-0.025
10^0
ω
10^{-1}
10^0
K


$10^{0.3}$
$10^{0.2}$
$10^{0.1}$
10^{0}
ω
$10^{0.1}$
$10^{0.2}$
$10^{0.3}$
K
0.01
0.008
0.006
0.004
0.002
0
-0.002
-0.004
-0.006
-0.008
-0.01