Программа построения векторов

$$V(a,z) := \begin{bmatrix} 0 \\ z \\ z + a\cdot e^{i\cdot(\arg(z)+167\cdot deg)} \\ z - a\cdot 0.5\cdot e^{i\cdot(\arg(z))} \\ z + a\cdot e^{i\cdot(\arg(z)-167\cdot deg)} \\ z \end{bmatrix}$$

$$Vec(A,x,i,s) := \left| \begin{array}{l} \begin{pmatrix} vx \\ vy \end{pmatrix} \leftarrow A\cdot\begin{bmatrix} (x^{\langle 1\rangle})_i \\ (x^{\langle 2\rangle})_i \end{bmatrix} \\ v \leftarrow \dfrac{vx + vy\cdot i}{|vx + vy\cdot i|} \\ z \leftarrow V(s, v\cdot 0.1) + (x^{\langle 1\rangle})_i + i\cdot(x^{\langle 2\rangle})_i \end{array} \right.$$

Исследуемая динамическая система

$$a_0\cdot\frac{d^2}{dt^2}x + a_1\cdot\frac{d}{dt}x + a_2\cdot x = f$$

$$\left| \begin{array}{l} \dfrac{d}{dt}x = y \\ \dfrac{d}{dt}y = -\dfrac{a_1}{a_0}\cdot y - \dfrac{a_2}{a_0}\cdot x + f \end{array} \right.$$

$$a := (1 \quad 3 \quad 2)^T \qquad A := \begin{pmatrix} 0 & 1 \\ -\dfrac{a_2}{a_0} & -\dfrac{a_1}{a_0} \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -2 & -3 \end{pmatrix} \qquad eigenvals(A) = \begin{pmatrix} -1 \\ -2 \end{pmatrix}$$

$$a_2 := |A| = 2 \qquad a_1 := -tr(A) = 3$$

Корни характеристического уравнения

$$z(p) := p^2 + a_1\cdot p + a_2 \qquad \lambda := z(p) \left| \begin{array}{l} solve \\ float, 5 \end{array} \right. \rightarrow \begin{pmatrix} -1.0 \\ -2.0 \end{pmatrix} \qquad N := 300$$

Точка положения равновесия - устойчивый узел

$$D(t,x) := A\cdot x \qquad T := 8 \qquad x(xo,yo) := rkfixed\left[\begin{pmatrix} xo \\ yo \end{pmatrix}, 0, T, N, D\right] \qquad t := x(0,10)^{\langle 0\rangle}$$

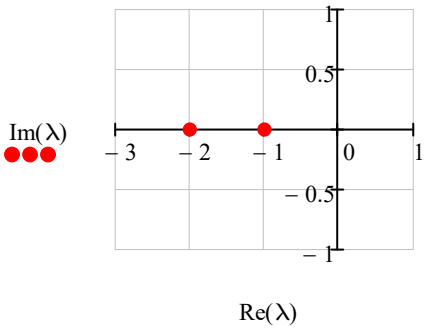
$$x1 := x(0,10) \qquad x2 := x(0,-10) \qquad x3 := x(0,20) \qquad x4 := x(0,-20)$$

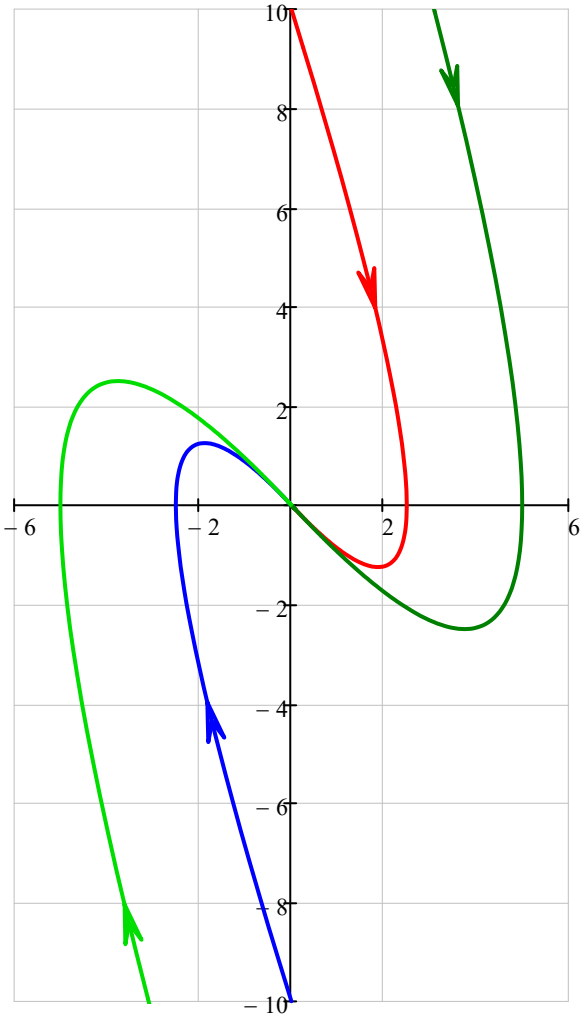
$$n := 10 \qquad s := 0.8$$

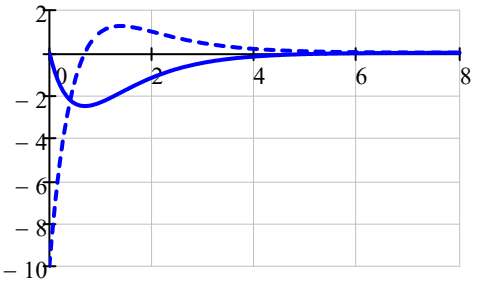
$$z1(n) := Vec(A,x1,n,s) \qquad z2(n) := Vec(A,x2,n,s)$$

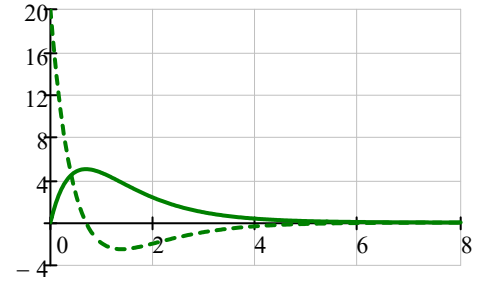
$$z4(n) := Vec(A,x4,n,s) \qquad z3(n) := Vec(A,x3,n,s)$$

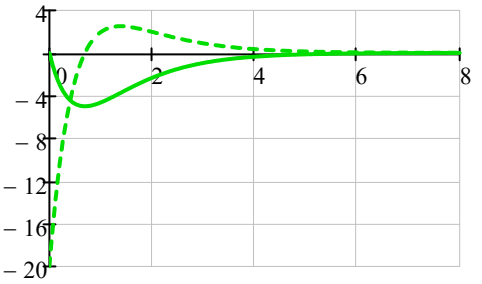
карта полюсов











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$$a_0 \cdot \frac{d^2}{dt^2} x + a_1 \cdot \frac{d}{dt} x + a_2 \cdot x = f$$

$$\begin{cases} \frac{d}{dt} x = y \\ \frac{d}{dt} y = -\frac{a_1}{a_0} \cdot y - \frac{a_2}{a_0} \cdot x + f \end{cases}$$

$$\left(x1^{\langle 1 \rangle}\right)_{N-2} = 0.0035$$

$$\left(x2^{\langle 2 \rangle}\right)_{N-2} = 0.0035$$

$$a := (1 \quad -3 \quad 2)^T$$

$$A := \begin{pmatrix} 0 & 1 \\ -\frac{a_2}{a_0} & -\frac{a_1}{a_0} \end{pmatrix} = \begin{pmatrix} 0 & 1 \\ -2 & 3 \end{pmatrix}$$

$$\text{eigenvals}(A) = \begin{pmatrix} 1 \\ 2 \end{pmatrix}$$

$$a_2 := |A| = 2 \qquad a_1 := -\text{tr}(A) = -3$$

Корни характеристического уравнения

$$To := 0$$

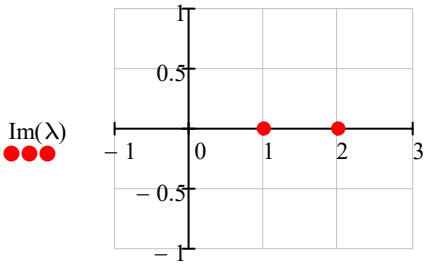
$$z(p) := p^2 + a_1 \cdot p + a_2$$

$$\lambda := z(p) \begin{vmatrix} \text{solve} \\ \text{float}, 5 \end{vmatrix} \rightarrow \begin{pmatrix} 1.0 \\ 2.0 \end{pmatrix}$$

$$N := 300$$

карта полюсов

точка положения равновесия - не устойчивый узел

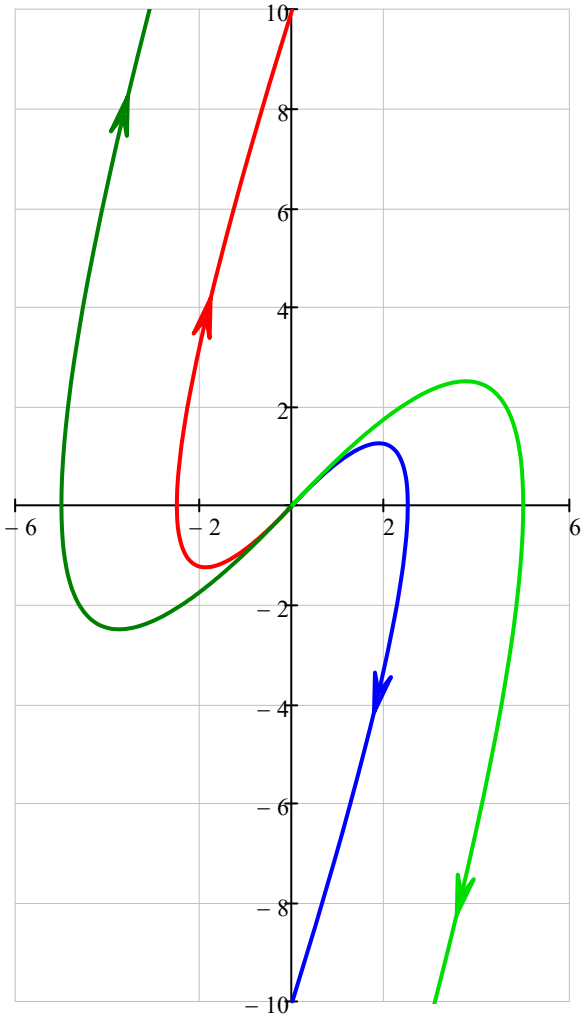


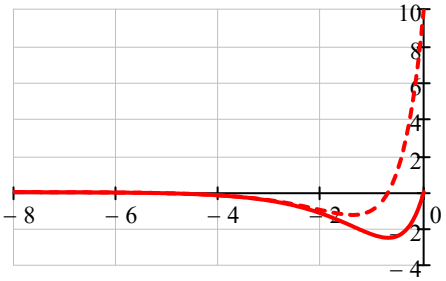
$D(t,x) := A \cdot x$ $T := 8$ $x(xo,yo) := \text{rkfixed}\left[\begin{pmatrix} xo \\ yo \end{pmatrix}, To, -T, N, D\right]$ $t := x(0,10)^{\langle 0 \rangle}$

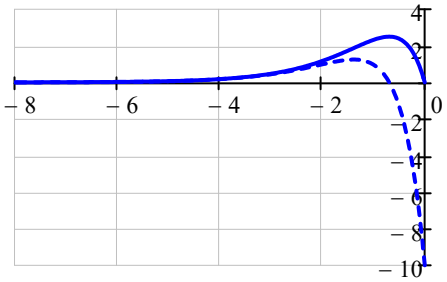
$x1 := x(0,10)$ $x2 := x(0,-10)$ $x3 := x(0,20)$ $x4 := x(0,-20)$ $n := 10$ $s := 0.8$

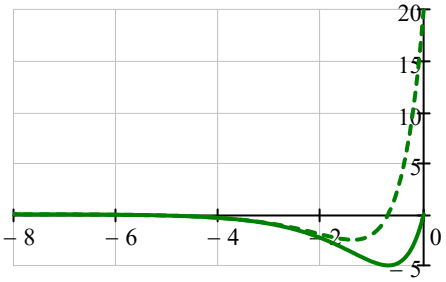
$z1(n) := Vec(A,x1,n,s)$ $z2(n) := Vec(A,x2,n,s)$

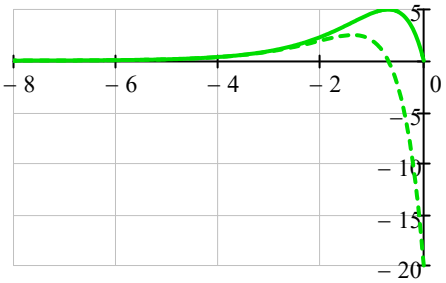
$z4(n) := Vec(A,x4,n,s)$ $z3(n) := Vec(A,x3,n,s)$











$$\begin{cases} \frac{d}{dt}x = 1x - 4y \\ \frac{d}{dt}y = 4x + y \end{cases}$$

$A := \begin{pmatrix} 1 & -4 \\ 4 & 1 \end{pmatrix}$ $a_1 := -tr(A) = -2$ $a_2 := |A| = 17$

$z(p) := p^2 + a_1 \cdot p + a_2$ $\lambda := z(p)$ $\begin{vmatrix} \text{solve}, p \\ \text{float}, 4 \end{vmatrix} \rightarrow \begin{pmatrix} 1.0 + 4.0i \\ 1.0 - 4.0i \end{pmatrix}$ $eigenvals(A) = \begin{pmatrix} 1 + 4i \\ 1 - 4i \end{pmatrix}$

$D(t,x) := A \cdot x$ $T := 5$ $N := 3 \cdot 10^2$ $x(x_0,y_0) := \text{rkfixed}\left[\begin{pmatrix} x_0 \\ y_0 \end{pmatrix}, 0, T, N, D\right]$ $\sigma := 10^6$ $s := 0.25$

$x1 := x(0.017, 0.012)$ $x2 := x(-0.0083, 0.018)$ $x3 := x(-0.02, -0.004)$

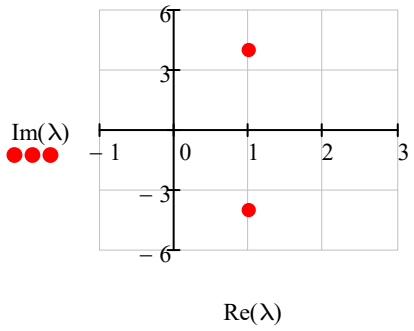
$z1(n) := Vec(A, x1, n, s)$ $z2(n) := Vec(A, x2, n, s)$

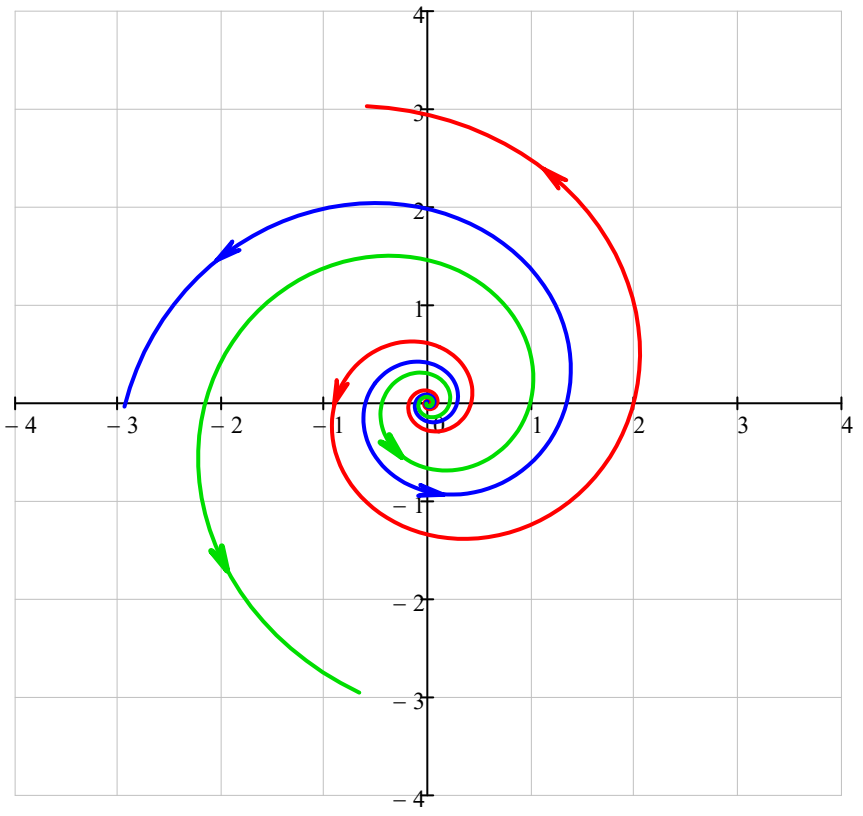
$Z1 := stack(z1(225), \sigma, z1(290))$ $Z2 := stack(z2(230), \sigma, z2(290))$

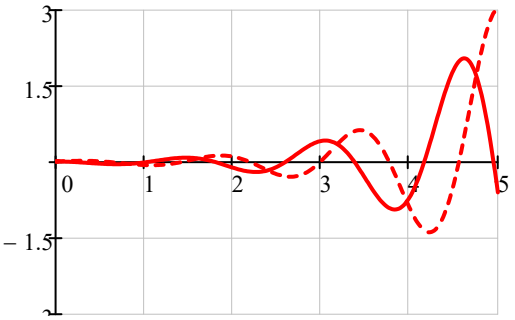
$z3(n) := Vec(A, x3, n, s)$

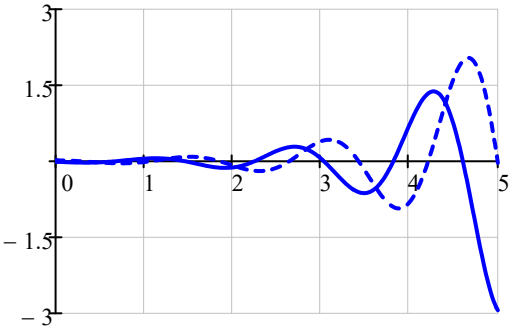
$Z3 := stack(z3(200), \sigma, z3(290))$

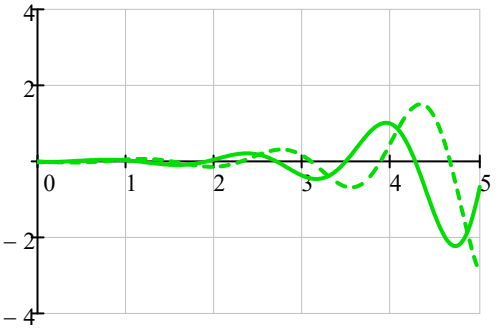
карта полюсов











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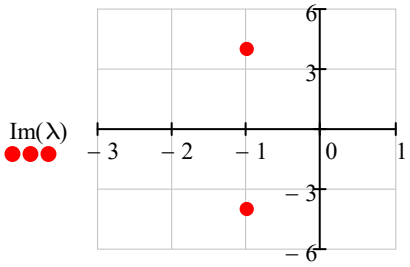
$$\begin{cases} \frac{d}{dt}x = -1x - 4y \\ \frac{d}{dt}y = 4x - y \end{cases} \qquad A := \begin{pmatrix} -1 & -4 \\ 4 & -1 \end{pmatrix} \qquad a_1 := -tr(A) = 2 \qquad a_2 := |A| = 17$$

$$z(p) := p^2 + a_1 \cdot p + a_2 \qquad \lambda := z(p) \begin{vmatrix} solve, p \\ float, 4 \end{vmatrix} \rightarrow \begin{pmatrix} -1.0 + 4.0i \\ -1.0 - 4.0i \end{pmatrix} \qquad eigenvals(A) = \begin{pmatrix} -1 + 4i \\ -1 - 4i \end{pmatrix}$$

$D(t, x) := A \cdot x$ $T := 5$ $N := 3 \cdot 10^2$

карта полюсов

$x(x_0, y_0) := \text{rkfixed}\left[\begin{pmatrix} x_0 \\ y_0 \end{pmatrix}, 0, T, N, D\right]$ $\sigma := 10^6$ $s := 0.25$

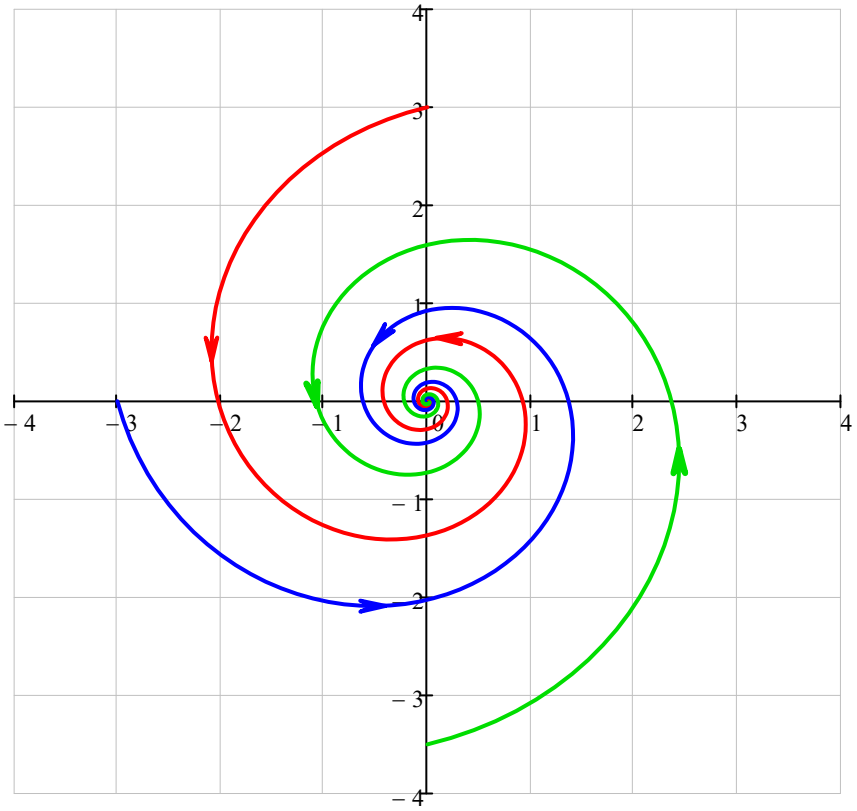


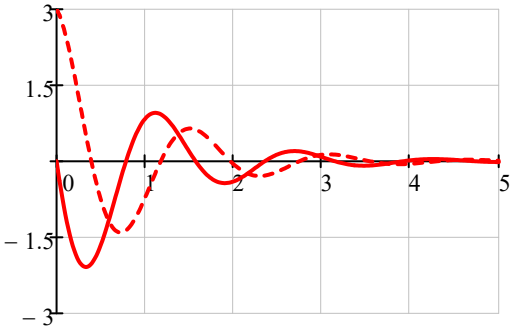
$x1 := x(0, 3)$ $x2 := x(-3, 0)$ $x3 := x(0, -3.5)$

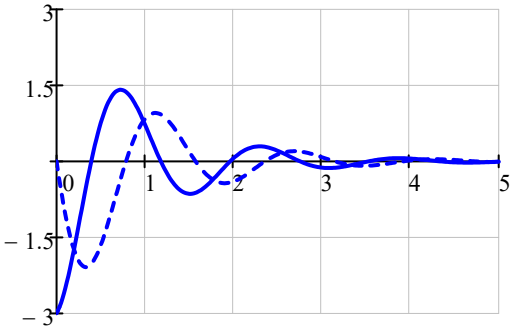
$z1(n) := Vec(A, x1, n, s)$
$Z1 := stack(z1(20), \sigma, z1(90))$

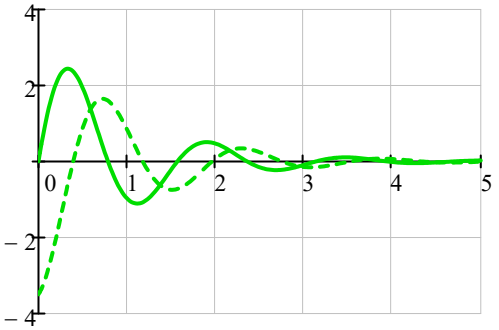
$z2(n) := Vec(A, x2, n, s)$
$Z2 := stack(z2(20), \sigma, z2(80))$

$z3(n) := Vec(A, x3, n, s)$ $Z3 := stack(z3(20), \sigma, z3(70))$









$$\begin{cases} \frac{d}{dt}x = 0 - 4y \\ \frac{d}{dt}y = 4x + 0 \end{cases}$$

$A := \begin{pmatrix} 0 & -4 \\ 4 & 0 \end{pmatrix}$ $a_1 := -tr(A) = 0$ $a_2 := |A| = 16$

$z(p) := p^2 + a_1 \cdot p + a_2$ $\lambda := z(p)$ $\begin{vmatrix} solve, p \\ float, 4 \end{vmatrix} \rightarrow \begin{pmatrix} 4.0i \\ -4.0i \end{pmatrix}$ $eigenvals(A) = \begin{pmatrix} 4i \\ -4i \end{pmatrix}$

$D(t, x) := A \cdot x$ $T := 5$ $N := 3 \cdot 10^2$

карта полюсов

$x(x_0, y_0) := \text{rkfixed}\left[\begin{pmatrix} x_0 \\ y_0 \end{pmatrix}, 0, T, N, D\right]$ $\sigma := 10^6$ $s := 0.3$

$x1 := x(0, 2)$ $x2 := x(-2.8, 0)$ $x3 := x(3.5, 0)$

$z1(n) := \text{Vec}(A, x1, n, s)$ $z2(n) := \text{Vec}(A, x2, n, s)$

$Z1 := \text{stack}(z1(55), \sigma, z1(100))$ $Z2 := \text{stack}(z2(35), \sigma, z2(80))$

$z3(n) := \text{Vec}(A, x3, n, s)$ $Z3 := \text{stack}(z3(35), \sigma, z3(85))$