

```

1 import numpy as np
2 import matplotlib.pyplot as plt
3 from scipy.integrate import odeint
4 import sys
5
6 xmin = -0.55
7 ymin = -0.55
8 xmax = 0.55
9 ymax = 0.55
10
11 # Streamplot
12 no_points = 1000
13 x_points = np.linspace(xmin, xmax, no_points)
14 y_points = np.linspace(ymin, ymax, no_points)
15 X, Y = np.meshgrid(x_points, y_points)
16
17 mu = -0.15
18 dxdt_streamplot = mu*X - 5*Y - X**2
19 dydt_streamplot = 5*X + mu*Y + 3*Y**3
20 # dxdt_streamplot = mu*X + Y - X**2
21 # dydt_streamplot = -X + mu*Y + 2*X**2
22
23 # Numerical integration
24 T = 100
25 t = np.linspace(0, T, T*100)
26 x = np.zeros(T)
27 y = x.copy()
28 fp = np.array([[0,0], [0,0]])
29 x[0] = fp[0,0] + 0.24
30 y[0] = fp[0,1] + 0.24
31 T2 = 21
32 t2 = np.linspace(0, T2, T2*100)
33 x2 = np.zeros(T2)
34 y2 = x2.copy()
35 x2[0] = fp[0,0] + 0.01
36 y2[0] = fp[0,1] - 0.01
37
38 def dynamical_system(xy, t):
39     mu = 0.15
40     x = xy[0]
41     y = xy[1]
42     dxdt_integration = mu*x - 5*y - x**2
43     dydt_integration = 5*x + mu*y + 3*y**3
44     # dxdt_integration = mu*x + y - x**2
45     # dydt_integration = -x + mu*y + 2*x**2
46     return [dxdt_integration, dydt_integration]
47
48 x0y0 = [x[0], y[0]]
49 xy = odeint(dynamical_system, x0y0, t)
50 x = xy[:,0]
51 y = xy[:,1]
52 x0y02 = [x2[0], y2[0]]
53 xy2 = odeint(dynamical_system, x0y02, t2)
54 x2 = xy2[:,0]
55 y2 = xy2[:,1]
56
57 fig, ax = plt.subplots(figsize=(7,7))
58 ax.streamplot(X, Y, dxdt_streamplot, dydt_streamplot, density = 2)

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59 # ax.plot(x, y, '-', color='red', linewidth=3, label='Trajectory going towards the
    stable node')
60 ax.plot(x2, y2, '-', color='orange', linewidth=3, label='Trajectory going away from
    the stable node')
61 ax.plot(fp[0,0],fp[0,1], '.', color='black', markersize=15, label='Stable node')
62 # ax.plot(fp[1,0],fp[1,1], '.', color='magenta', markersize=15, label='Unstable
    spiral')
63 ax.set_title('2.3: Dynamical system 1,  $\mu = 0.15$ ; indication of subcritical
    bifurcation ( $a > 0$ )')
64 ax.set_xlabel('x')
65 ax.set_ylabel('y')
66 ax.set_xlim(xmin,xmax)
67 ax.set_ylim(xmin,xmax)
68 ax.set_box_aspect(1)
69
70 plt.legend(loc="upper left")
71 plt.savefig('23_d1mu0.15.png', bbox_inches='tight')
72 plt.show()
73
```