Plot library

appVersion(4) = "0.99.7921.69"

PLOT

Functions

Some functions used here

$$peaks(x, y) := 3 \cdot \frac{(1-x)^2}{e^{x^2 + (y+1)^2}} - 10 \cdot \frac{\frac{x}{5} - x^3 - y^5}{e^{x^2 + y^2}} - \frac{1}{3 \cdot e^{(x+1)^2 + y^2}}$$

$$torus(u, v, R, r) := \begin{bmatrix} (R + r \cdot \cos(u)) \cdot \cos(v) \\ (R + r \cdot \cos(u)) \cdot \sin(v) \\ r \cdot \sin(u) \end{bmatrix} \qquad torus(u, v) := torus(u, v, 6, 2)$$

$$rev_z(t, \beta) := \begin{bmatrix} \cos(\beta) & \sin(\beta) & 0 \\ -\sin(\beta) & \cos(\beta) & 0 \\ 0 & 0 & 1 \end{bmatrix} \cdot \begin{bmatrix} 5 \cdot \sqrt{t} \\ 4 \cdot \cos(t) \\ 2 \cdot \sin(t) \end{bmatrix}$$

$$wave(r, \theta) := cyl2xyz\left(\begin{bmatrix} r & \theta & 0.5 \cdot \cos(4 \cdot r) \end{bmatrix}\right)$$

$$mobius(t, s, r) := \begin{bmatrix} \left(r + s \cdot \cos\left(\frac{t}{2}\right)\right) \cdot \cos(t) \\ \left(r + s \cdot \cos\left(\frac{t}{2}\right)\right) \cdot \sin(t) \\ s \cdot \sin\left(\frac{t}{2}\right) \end{bmatrix} \qquad mobius(t, s) := mobius(t, s, 5)$$

$bottle(u, v) :=$

```
[ bx := 6·cos(u)·(1 + sin(u))   by := 16·sin(u)   r := 4·(1 − 0.5·cos(u)) ]
if π < u
    stack(bx + r·cos(v + π), by, r·sin(v))
else
    stack(bx + r·cos(u)·cos(v), by + r·sin(u)·cos(v), r·sin(v))
```

$$roman(u, v, r) := \begin{bmatrix} \sin(r \cdot u) \cdot \sin(v)^2 \\ \sin(u) \cdot \cos(r \cdot v) \\ \cos(u) \cdot \sin(r \cdot v) \end{bmatrix} \qquad roman(u, v) := roman(u, v, 2)$$

pMesh Notation

pMesh Notation

$pMesh(F, X, Y)$ where $F(x, y) = \varphi_{scalar}(x, y)$ $\qquad 1.5 \cdot \pi = 270$ deg

$pMesh(F, B, N)$ $\qquad F(u, v) = \begin{bmatrix} x(u, v) & y(u, v) & z(u, v) \end{bmatrix}$

Examples

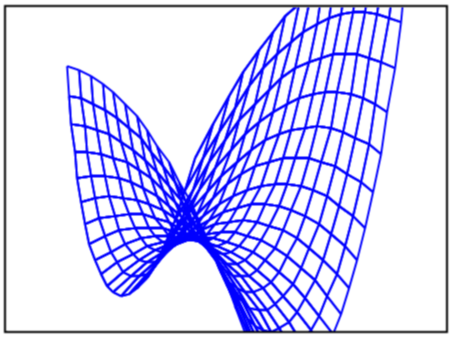
$X := pR(-4, 4, 20)$

$Y := pR(-3, 3, 16)$

$$\left[B := \begin{bmatrix} -4 & 4 \\ -2 & 2 \end{bmatrix} \; N := \begin{bmatrix} 20 \\ 16 \end{bmatrix} \right]$$

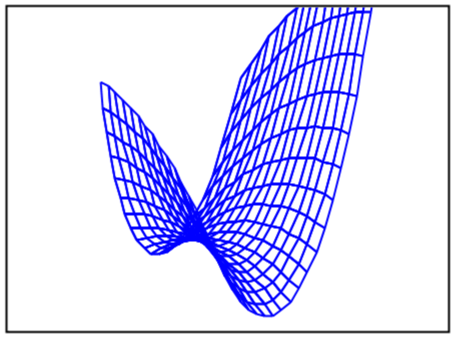
$f_1(x, y) := 0.3 \cdot \left(x^2\right) - 0.2 \cdot y^2 - 0.3 \cdot x \cdot y - 2$ $\qquad f_2(x, y) := \begin{bmatrix} x & y & f_1(x, y) \end{bmatrix}$

$S_1 := pMesh("f.1", X, Y)$



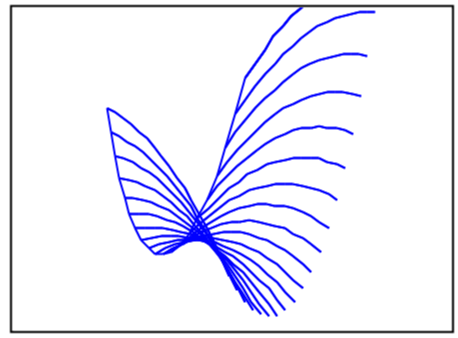
$S_1 \cdot \gamma \cdot 2$

$S_2 := pMesh("f.2", B, N)$



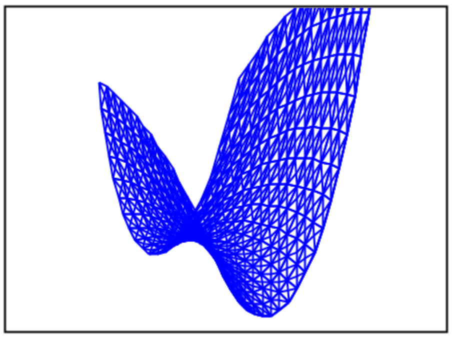
$S_2 \cdot \gamma \cdot 2$

$S_3 := pWXMesh("f.1", B, N)$



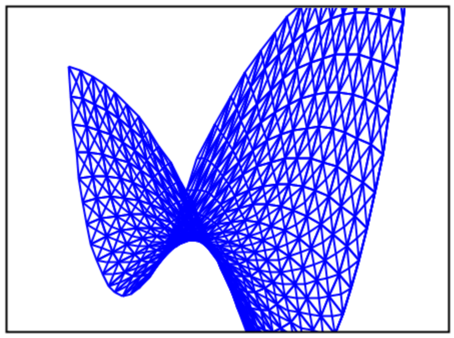
$S_3 \cdot \gamma \cdot 2$

$S_1 := pTMesh("f.1", B, N)$



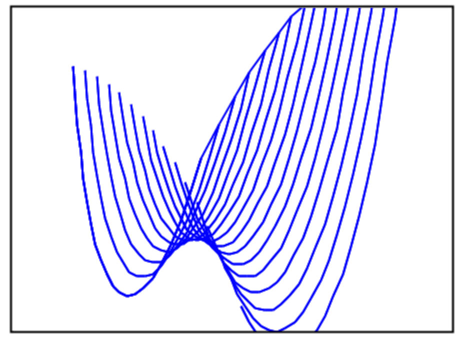
$S_1 \cdot \gamma \cdot 2$

$S_2 := pTMesh("f.2", X, Y)$



$S_2 \cdot \gamma \cdot 2$

$S_3 := pWYMesh("f.2", X, Y)$



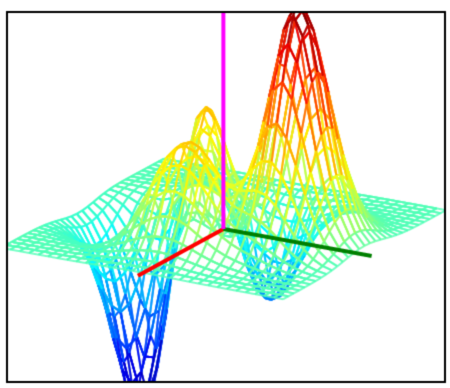
$S_3 \cdot \gamma \cdot 2$

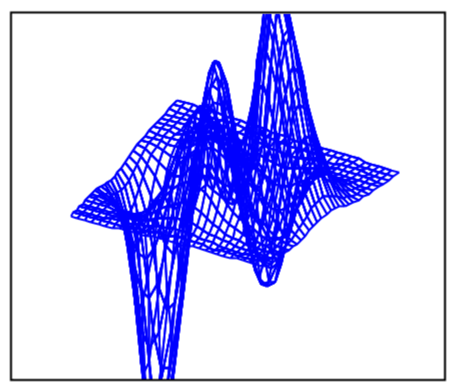
⊟ Mesh

Mesh plots

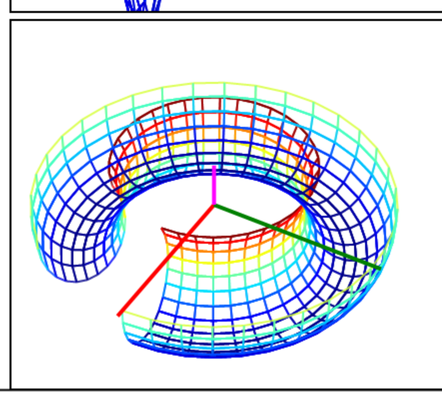
2D XY plugin plot | **3D Native SMath plot**

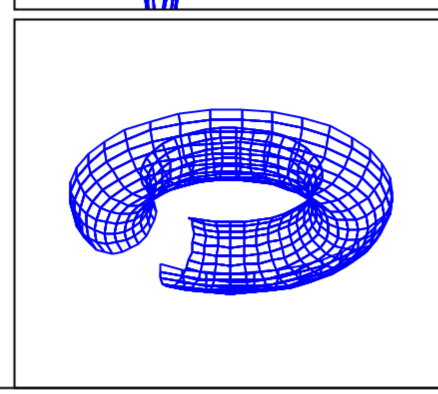
$X := pR(-3, 3, 30)$
$Y := pR(-3, 3, 30)$
$S := pMesh(peaks, X, Y)$
$P_1 := pShow(S, CMap, \gamma)$
$P_2 := S \cdot \gamma \cdot 2$



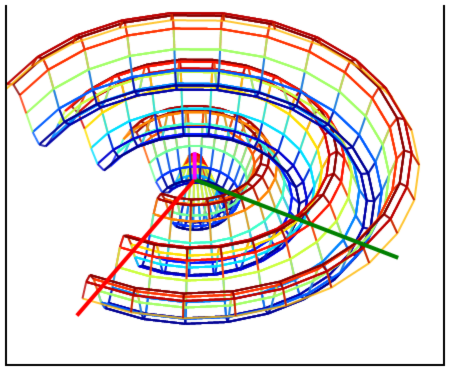
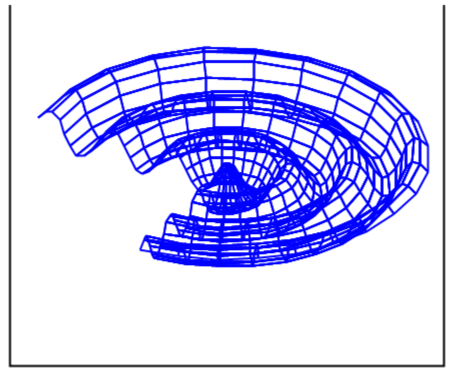


$U := pR(-1.25 \cdot \pi, 0, 16)$
$V := pR(0, 1.75 \cdot \pi, 32)$
$S := pMesh(torus, U, V)$
$P_1 := pShow(S, CMap, \gamma)$
$P_2 := S \cdot \gamma \cdot 1$

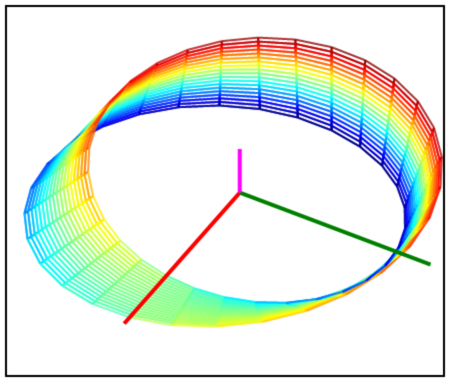
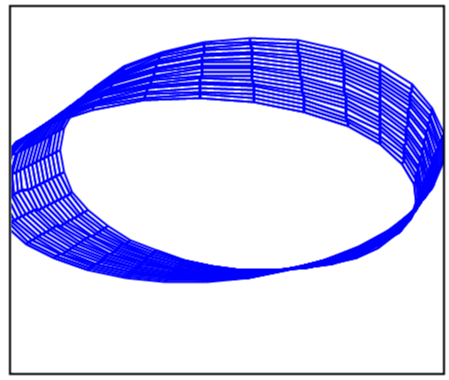




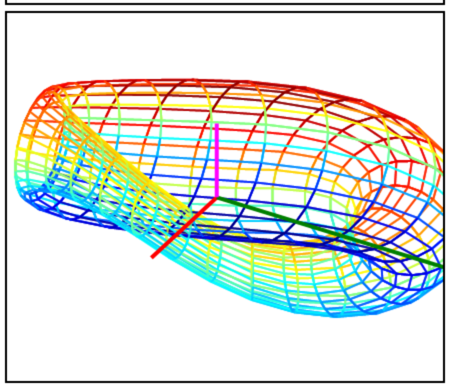
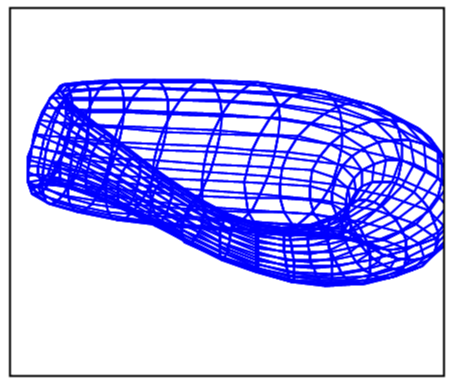
$V := pR(0, 1.5 \cdot \pi, 20)$
$S := pMesh(wave, U, V)$
$P_1 := pShow(S, CMap, \gamma)$
$P_2 := S \cdot \gamma \cdot 2$

$B := \begin{bmatrix} 0 & 2 \cdot \pi \\ -1 & 1 \end{bmatrix} \quad N := \begin{bmatrix} 30 \\ 18 \end{bmatrix}$
$S := pMesh(mobius, B, N)$
$P_1 := pShow(S, CMap, \gamma)$
$P_2 := S \cdot \gamma \cdot 2$

$B := \begin{bmatrix} 0 & 2 \cdot \pi \\ 0 & 2 \cdot \pi \end{bmatrix} \quad N := \begin{bmatrix} 25 \\ 25 \end{bmatrix}$
$S := pMesh(bottle, B, N)$
$P_1 := pShow(S, CMap, \gamma)$
$P_2 := S \cdot \gamma \cdot 0.6$

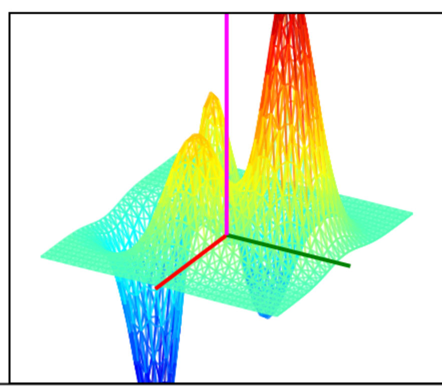
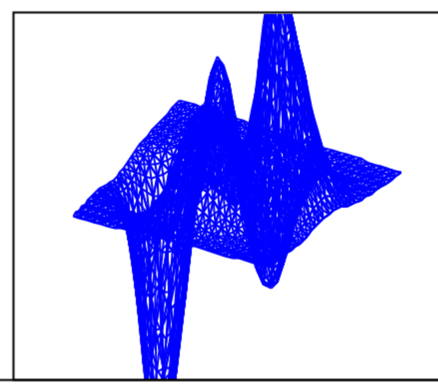



TriMesh

Trimesh plots

2D XY plugin plot | **3D Native SMath plot**

$X := pR(-3, 3, 30)$
$Y := pR(-3, 3, 30)$
$S := pTMesh(peaks, X, Y)$
$P_1 := pShow(S, CMap, \gamma)$
$P_2 := S \cdot \gamma \cdot 2$

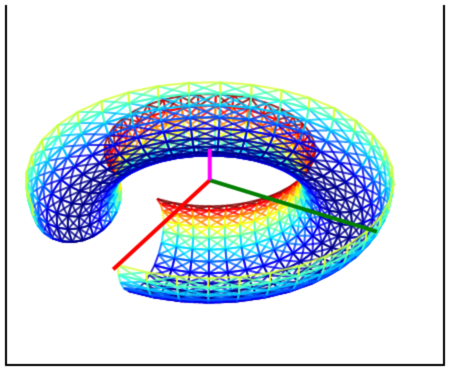



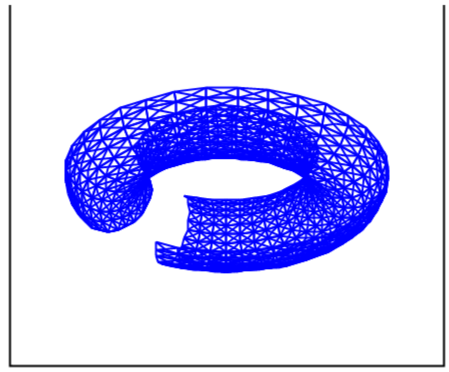
$V := pR(0, 1.75 \cdot \pi, 32)$

$S := pTMesh(torus, U, V)$

$P_1 := pShow(S, CMap, \gamma)$

$P_2 := S \cdot \gamma \cdot 1$





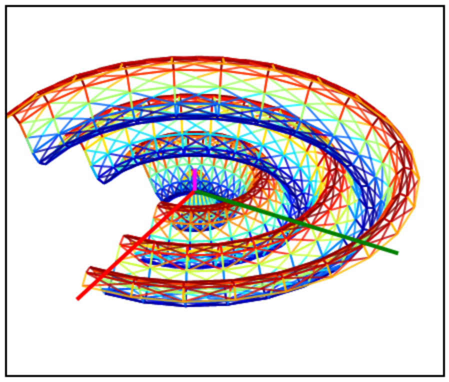
$U := pR(0, 5, 30)$

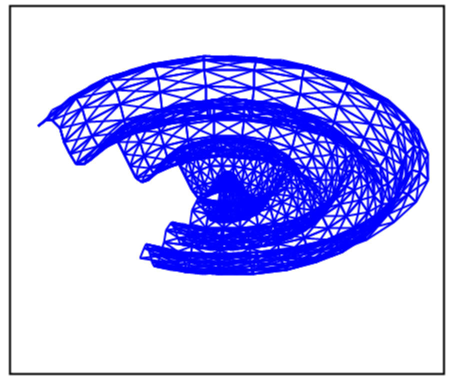
$V := pR(0, 1.5 \cdot \pi, 20)$

$S := pTMesh(wave, U, V)$

$P_1 := pShow(S, CMap, \gamma)$

$P_2 := S \cdot \gamma \cdot 2$



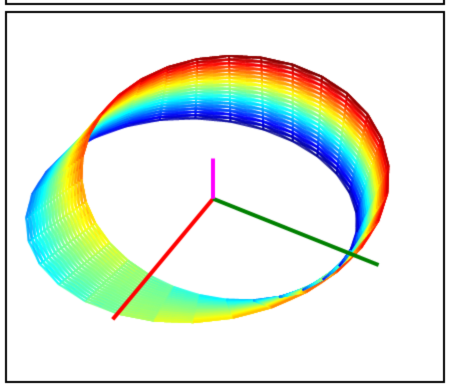


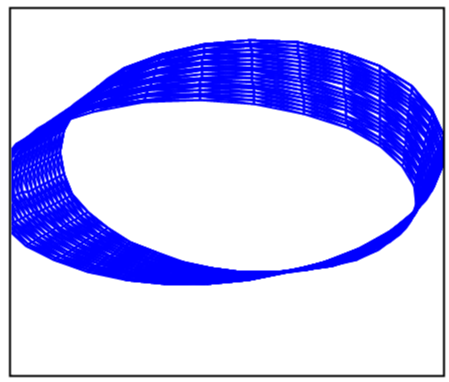
$\left[B := \begin{bmatrix} 0 & 2 \cdot \pi \\ -1 & 1 \end{bmatrix} \; N := \begin{bmatrix} 30 \\ 18 \end{bmatrix} \right]$

$S := pTMesh(mobius, B, N)$

$P_1 := pShow(S, CMap, \gamma)$

$P_2 := S \cdot \gamma \cdot 2$



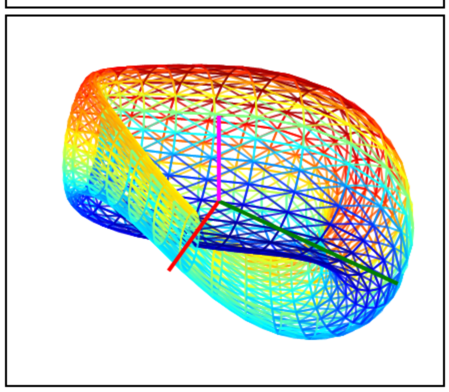


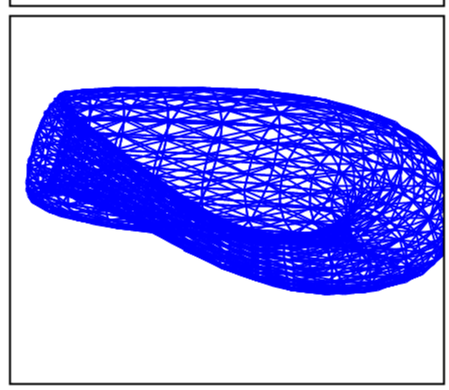
$\left[B := \begin{bmatrix} 0 & 2 \cdot \pi \\ 0 & 2 \cdot \pi \end{bmatrix} \; N := \begin{bmatrix} 25 \\ 25 \end{bmatrix} \right]$

$S := pTMesh(bottle, B, N)$

$P_1 := pShow(S, CMap, \gamma)$

$P_2 := S \cdot \gamma \cdot 0.6$

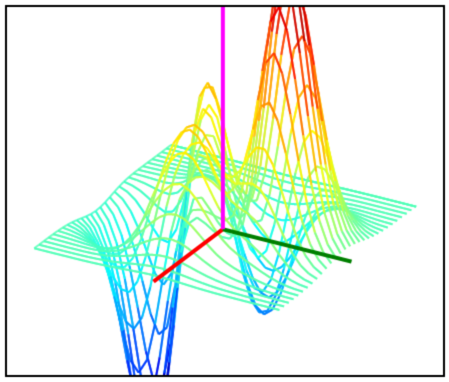


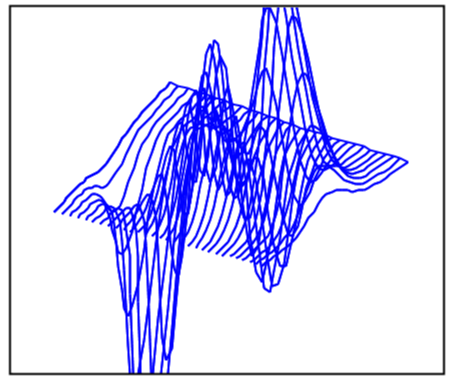


Waterrall plots

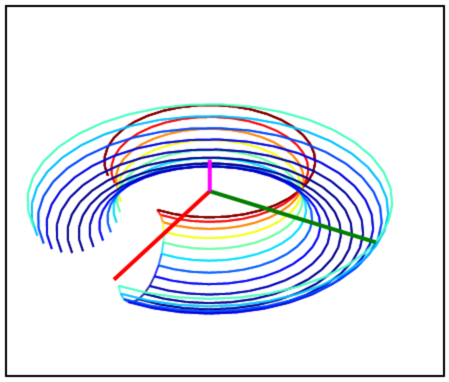
2D XY plugin plot | **3D Native SMath plot**

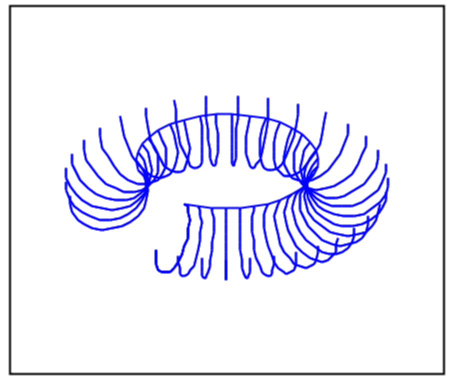
$X := pR(-3, 3, 30)$
$Y := pR(-3, 3, 30)$
$S_1 := pWXMesh(peaks, X, Y)$
$P_1 := pShow(S_1, CMap, \gamma)$
$S_2 := pWYMesh(peaks, X, Y)$
$P_2 := S_2 \cdot \gamma \cdot 2.2$



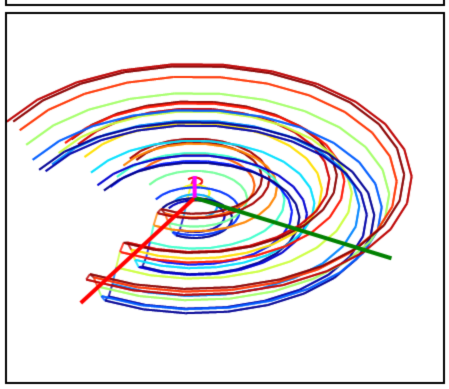


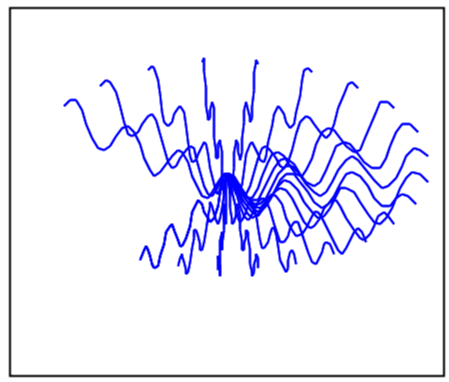
$U := pR(-1.25 \cdot \pi, 0, 16)$
$V := pR(0, 1.75 \cdot \pi, 32)$
$S_1 := pWXMesh(torus, U, V)$
$P_1 := pShow(S_1, CMap, \gamma)$
$S_2 := pWYMesh(torus, U, V)$
$P_2 := S_2 \cdot \gamma \cdot 1$



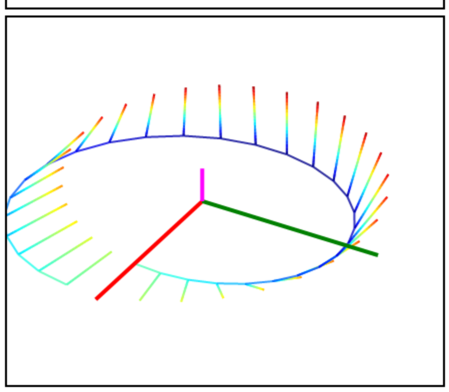


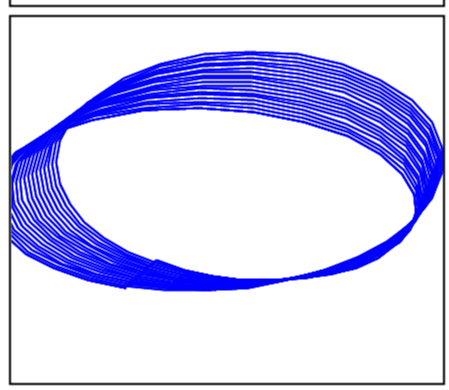
$U := pR(0, 5, 30)$
$V := pR(0, 1.5 \cdot \pi, 20)$
$S_1 := pWXMesh(wave, U, V)$
$P_1 := pShow(S_1, CMap, \gamma)$
$S_2 := pWYMesh(wave, U, V)$
$P_2 := S_2 \cdot \gamma \cdot 2$



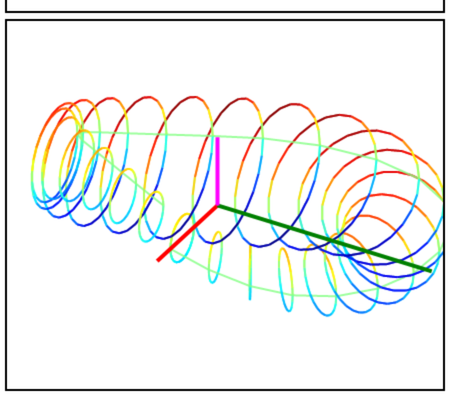


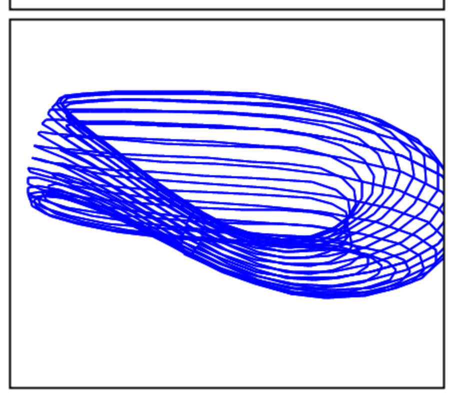
$$\left[B := \begin{bmatrix} 0 & 2 \cdot \pi \\ -1 & 1 \end{bmatrix} \quad N := \begin{bmatrix} 30 \\ 18 \end{bmatrix} \right]$$
$S_1 := pWXMesh(mobius, B, N)$
$P_1 := pShow(S_1, CMap, \gamma)$
$S_2 := pWYMesh(mobius, B, N)$
$P_2 := S_2 \cdot \gamma \cdot 2$





$$\left[B := \begin{bmatrix} 0 & 2 \cdot \pi \\ 0 & 2 \cdot \pi \end{bmatrix} \quad N := \begin{bmatrix} 25 \\ 25 \end{bmatrix} \right]$$
$S_1 := pWXMesh(bottle, B, N)$
$P_1 := pShow(S_1, CMap, \gamma)$
$S_2 := pWYMesh(bottle, B, N)$
$P_2 := S_2 \cdot \gamma \cdot 0.6$

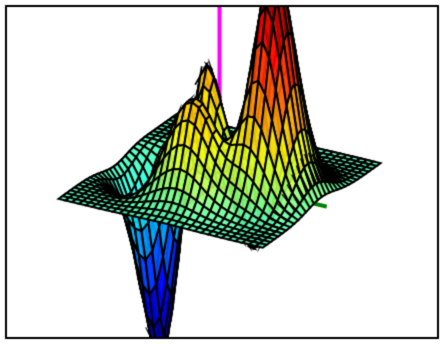


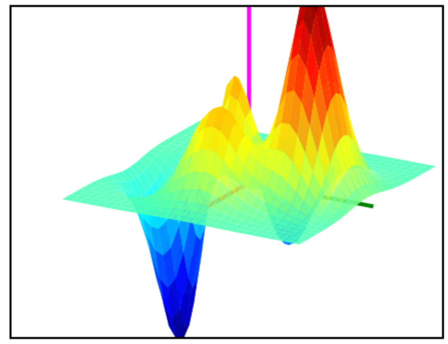


pShow

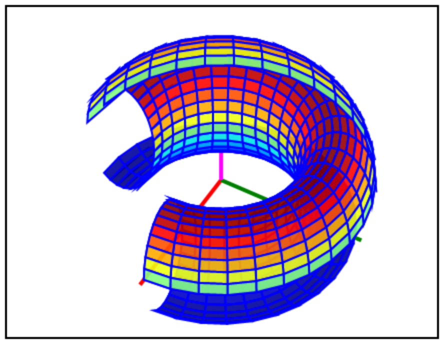
3D Srface Plot

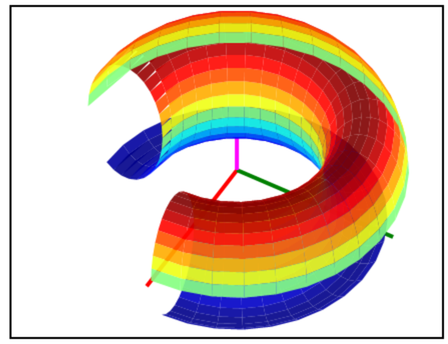
```
N := [30 30]
X := pR(−3, 3, N_1)
Y := pR(−3, 3, N_2)
S := pMesh(peaks, X, Y)
GM := pCMap("black")
GS := pCMap("Jet", 200, 0.9)
P_1 := pShow(S, N, γ, GM, GS)
P_2 := pShow(S, N, γ, 0, GS)
```



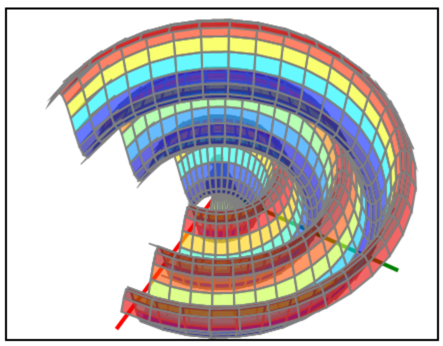


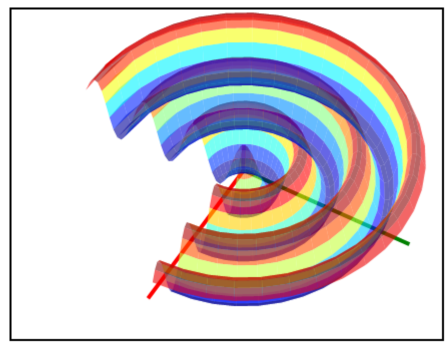
```
B := [0 300°; 0 270°]   N := [25; 25]
S := pMesh(torus, B, N)
GM := pCMap("blue", 1, 0.9)
GS := pCMap("Jet", 200, 0.9)
P_1 := pShow(S, −N, γ, GM, GS)
P_2 := pShow(S, −N, γ, 0, GS)
```



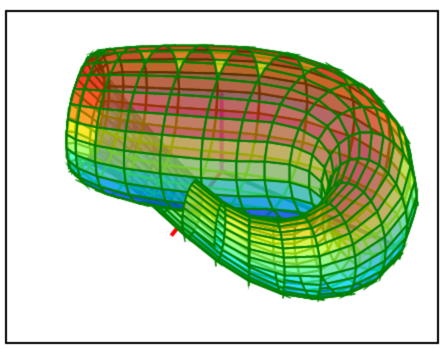


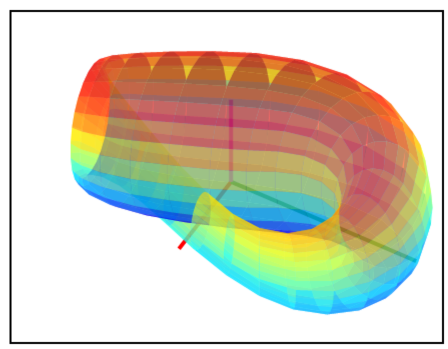
```
B := [0 5; 0 1.5·π]   N := [40; 30]
S := pMesh(wave, B, N)
GM := pCMap("gray", 1, 0.6)
GS := pCMap("Jet", 200, 0.6)
P_1 := pShow(S, N, γ, GM, GS)
P_2 := pShow(S, N, γ, 0, GS)
```



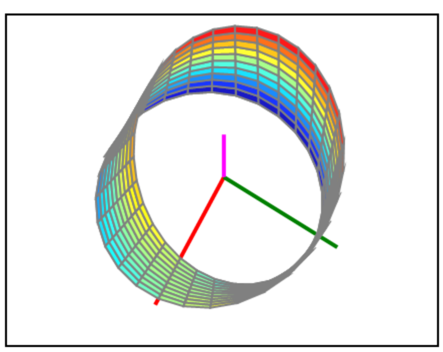


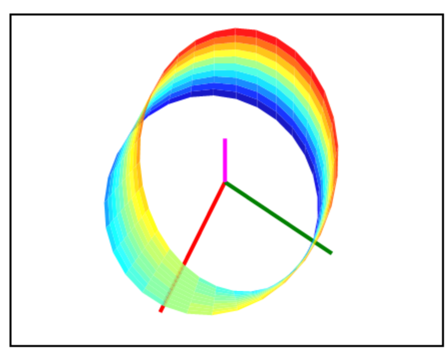
```
B := [0 2·π; 0 2·π]   N := [25; 25]
S := pMesh(bottle, B, N)
GM := pCMap("green")
GS := pCMap("Jet", 200, 0.6)
P_1 := pShow(S, −N, γ, GM, GS)
P_2 := pShow(S, −N, γ, 0, GS)
```





```
B := [0 2·π; −1 1]   N := [30; 10]
S := pMesh(mobius, B, N)
GM := pCMap("gray")
GS := pCMap("Jet", 32, 0.9)
P_1 := pShow(S, N, γ, GM, GS)
P_2 := pShow(S, N, γ, 0, GS)
```





$B := \begin{bmatrix} \cdots \\ 0 & 2\cdot\pi \end{bmatrix}$ $N := \begin{bmatrix} \cdots \\ 40 \end{bmatrix}$

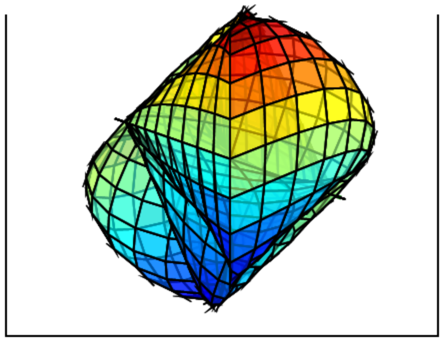
$S := pMesh(roman, B, N)$

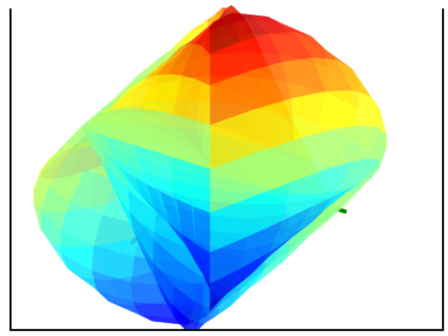
$GM := pCMap(\text{"black"}, 1, 1)$

$GS := pCMap(\text{"Jet"}, 32, 0.4)$

$P_1 := pShow(S, N, \gamma, GM, GS)$

$P_2 := pShow(S, N, \gamma, 0, GS)$





pAdapt complex

Adaptive Plot

Cartesians: $f(x) = x + i\cdot f(x)$

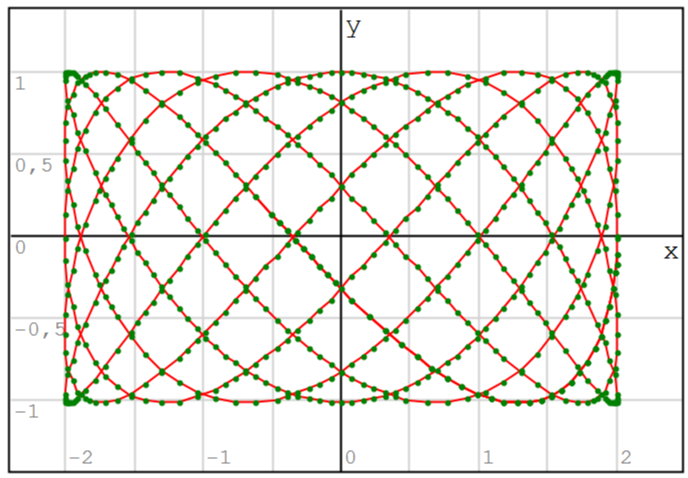
Polars: $\rho(\theta) = \rho(\theta)\cdot e^{i\cdot\theta}$

Parametrics: $z(t) = x(t) + i\cdot y(t)$

$z(t) := 2\cdot\cos(5\cdot t) + i\cdot\sin(9\cdot t)$

$XY := ReIm(pAdapt(z, 0, 2\cdot\pi))$

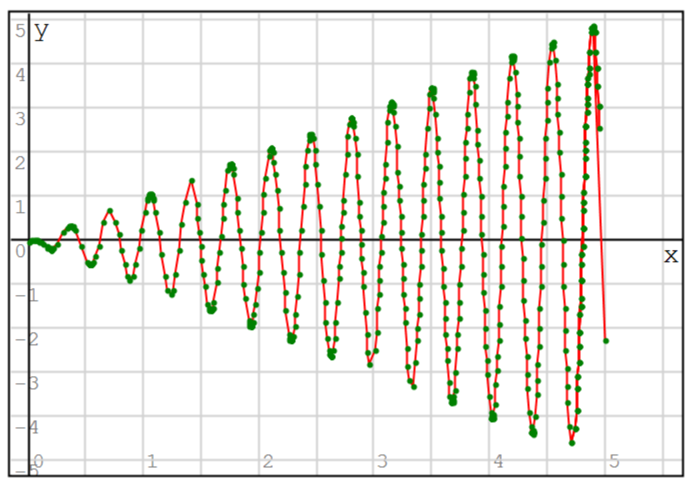
$\Pi := \begin{cases} \text{augment}(XY, \text{"."}, 8, \text{"green"}) \\ XY \end{cases}$



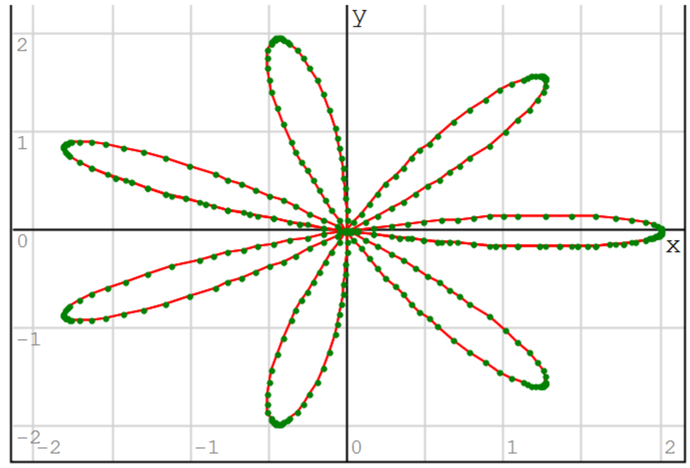
$f(x) := x + i\cdot x\cdot\cos(18\cdot x)$

$XY := ReIm(pAdapt(f, 0, 5))$

$\Pi := \begin{cases} \text{augment}(XY, \text{"."}, 8, \text{"green"}) \\ XY \end{cases}$



$$\rho(\theta) := 2\cdot\cos(7\cdot\theta)\cdot e^{i\cdot\theta}$$
$$XY := ReIm(pAdapt(\rho, 0, 2\cdot\pi))$$
$$\Pi := \begin{cases} augment(XY, ".", 8, "green") \\ XY \end{cases}$$



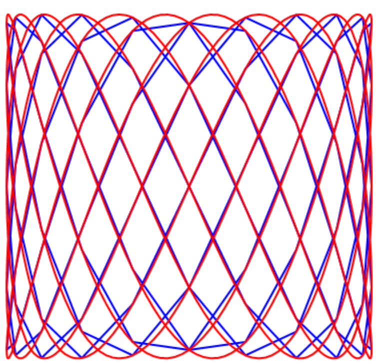
---

pAdapt parametric

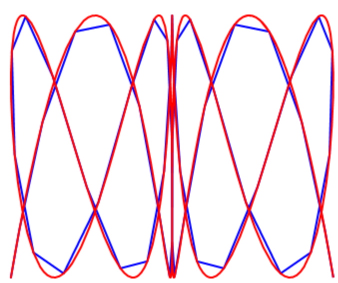
pAdapt for parametric curves

$$t := pR(0, 2\cdot\pi, 100)$$

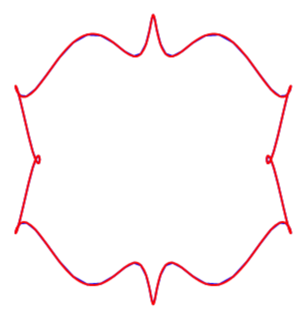
$$f_1(t) := \begin{bmatrix} \cos(5\cdot t) \\ \sin(12\cdot t) \end{bmatrix} \qquad f_2(t) := \begin{bmatrix} (\cos(3\cdot t))^3 \\ (\sin(7\cdot t))^2 \end{bmatrix} \qquad f_3(t) := \begin{bmatrix} 6\cdot\cos(t) - \cos(5\cdot t) \\ 7\cdot\sin(t) - \sin(11\cdot t) \end{bmatrix}$$



$$\begin{cases} f_1(\mathbf{t}) \\ ReIm(pAdapt("f.1", 0, 2\cdot\pi)) \end{cases}$$



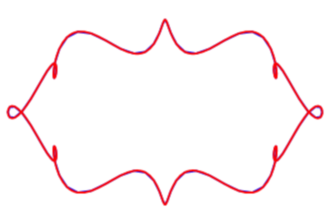
$$\begin{cases} f_2(\mathbf{t}) \\ ReIm(pAdapt("f.2", 0, 2\cdot\pi)) \end{cases}$$



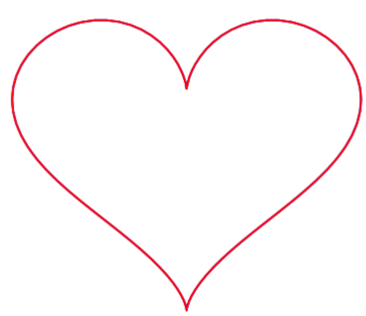
$$\begin{cases} f_3(\mathbf{t}) \\ ReIm(pAdapt("f.3", 0, 2\cdot\pi)) \end{cases}$$

$$f_1(t) := \begin{bmatrix} 9\cdot\cos(t) + \cos(7\cdot t) \\ 5\cdot\sin(t) - \sin(11\cdot t) \end{bmatrix} \qquad f_2(t) := \begin{bmatrix} 16\cdot(\sin(t))^3 \\ 13\cdot\cos(t) - 5\cdot\cos(2\cdot t) - 2\cdot\cos(3\cdot t) - \cos(4\cdot t) \end{bmatrix}$$

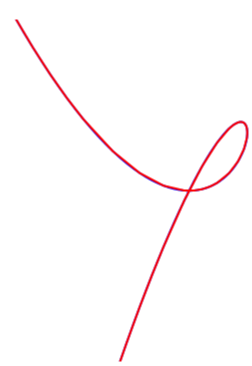
$$f_3(t) := \begin{bmatrix} t\cdot(2-t) \\ t^2\cdot(2-t) \end{bmatrix} \qquad t_3 := pR(-1, 3, 100)$$



$$\begin{cases} f_1(\mathbf{t}) \\ ReIm(pAdapt("f.1", 0, 2\cdot\pi)) \end{cases}$$



$$\begin{cases} f_2(\mathbf{t}) \\ ReIm(pAdapt("f.2", 0, 2\cdot\pi)) \end{cases}$$



$$\begin{cases} f_3(\mathbf{t_3}) \\ ReIm(pAdapt("f.3", -1, 3)) \end{cases}$$

pContour

Implicit plots

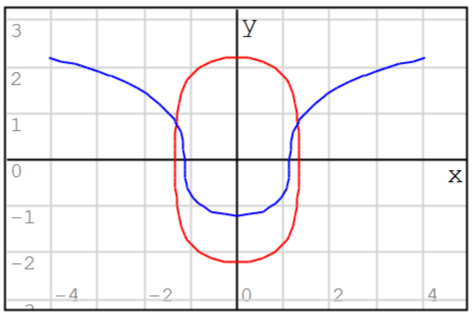
$f_1(x, y) := 4 \cdot x^2 - 7 \cdot y^3 - 12 \cdot \cos(x)$

$f_2(x, y) := 4 \cdot x^4 + 2 \cdot y^4 - 45 \cdot \cos(x)$

$B := \begin{bmatrix} -4 & 4 \\ -3 & 3 \end{bmatrix}$ $N := 6 \cdot \begin{bmatrix} 10 \\ 10 \end{bmatrix}$ Only takes Box notation

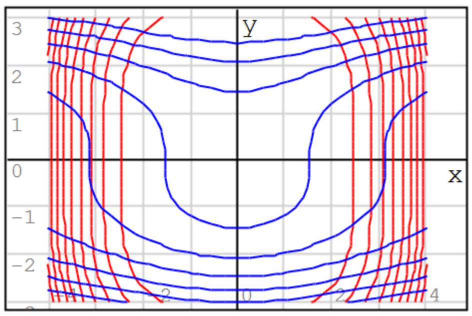
$[X\ Y] := pGrid(B, N)$ $G_1 := pRGrid(f_1, X, Y)$ $G_2 := pRGrid(f_2, X, Y)$

Implicit plot, direct call of f



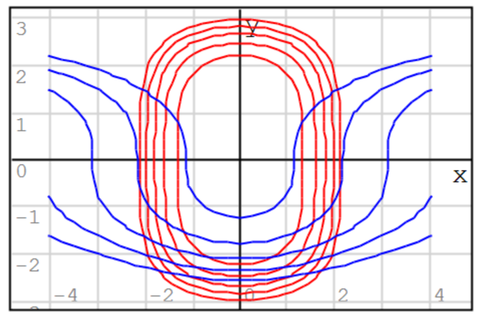
$\begin{cases} pCycleC(pContour(\text{"f.1"}, X, Y)) \\ pCycleC(pContour(\text{"f.2"}, X, Y)) \end{cases}$

10 level courves between max and min of f in the box



$\begin{cases} pCycleC(pContour(G_1, X, Y, 9)) \\ pCycleC(pContour(G_2, X, Y, 9)) \end{cases}$

5 level courves between 0 and 100



$\begin{cases} pCycleC(pContour(G_1, X, Y, pR(0, 100, 4))) \\ pCycleC(pContour(G_2, X, Y, pR(0, 100, 4))) \end{cases}$

pFillContour

Filled 2-D contour plot

$pFillContour(f, B, N, CM)$ plots the filled contour of f in the box B with N1xN2 rectangles with colors in CM $B = \begin{bmatrix} x1 & x2 \\ y1 & y2 \end{bmatrix}$ $N = \begin{bmatrix} nx \\ ny \end{bmatrix}$

$CM := pCMap(\text{"Jet"}, 200, 1)$ creates a Jet colormap of n colors with a transparency

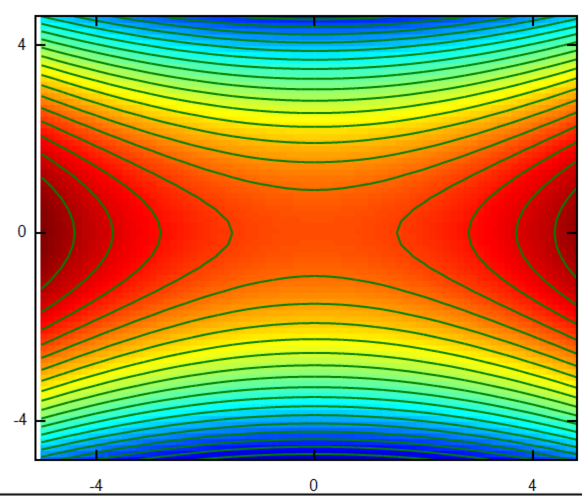
$f(x, y) := x^2 - 4 \cdot y^2$

$\left[B := \begin{bmatrix} -5 & 5 \\ -5 & 5 \end{bmatrix} \quad N := \begin{bmatrix} 80 \\ 80 \end{bmatrix} \right]$

$C := pContour(f, B, N, 20)$

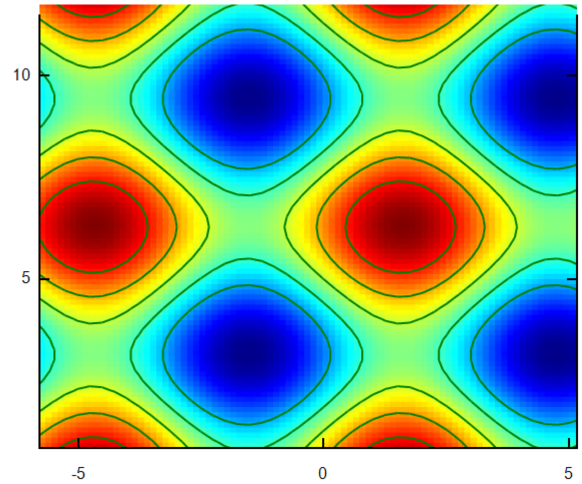
$FC := pFillContour(f, B, N, CM)$

$Plot := \text{stack}\left(FC, \left[\overrightarrow{pLine(C, \text{"green"})}\right]\right)$



This other call is more efficient because function is evaluated only once for the grid points

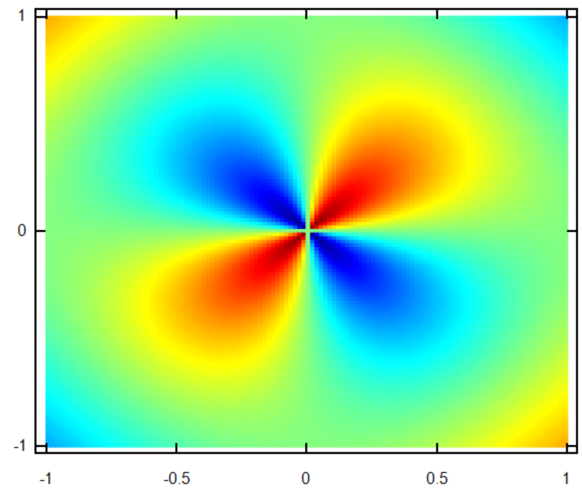
```
B := [ -2·π  2·π ]   N := [ 100 ]
     [  0    4·π ]        [ 100 ]
[X Y] := pGrid(B, N)
G := pRGrid(f, X, Y)
C := pContour(G, X, Y, 5)
FC := pFillContour(G, B, N, CM)
Plot := stack(FC, [pLine(C, "green")→])
```



Also, you can plot only the filled contour:

Contours of a polar function z(ρ,ϕ) = sin(2ϕ)(1-ρ)

```
f(x, y) := | [ρ φ] := [ |x + i·y|  atan(y, x) ]
           | sin(2·φ)·(1 − ρ)
X := pR(−1, 1, 120)
Y := pR(−1, 1, 120)
Plot := pFillContour(f, X, Y, CM)
```



⊟—pQuiver

Vector Fields Quiver Examples

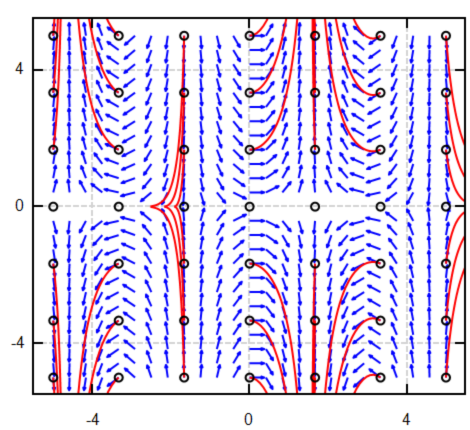
https://en.wikipedia.org/wiki/Integral_curve

Notation "Box":

```
B = [ xmin  xmax ]    N = [ nx ]    CM := pCMap("Jet", 200, 1)
    [ ymin  ymax ]        [ ny ]
```

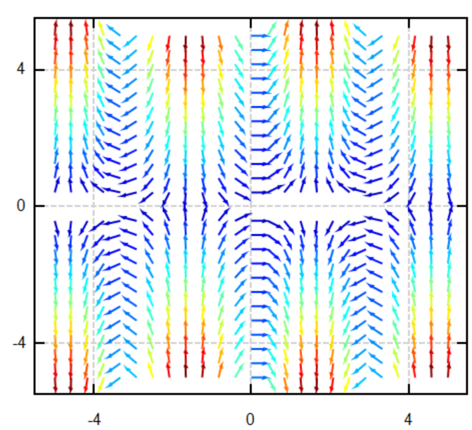
```
f(x, y) := [ √|y| · cos(x) ]
           [ 2·y·sin(x)    ]
[ B := [ −5 5 ]   N_IC := [ 6 ]   N_Q := 4·N_IC ]
       [ −5 5 ]           [ 6 ]
G := pGrid("f", B, N_Q)
Q := pQuiver("f", B, N_Q)
cm := pClr(norme(G)→, CM)
RK(x, y) := pRK("f", x, y, 4)
IC := pGrid("RK", B, N_IC)
O := augment(row(IC, 1), "o", 4)→
        { pCycleC(Q)
Plot := { pCycleC(IC)
        { pCycleC(O)
```

Ingegral Curves & monochrome VF



Plot

Map Colored Vector Field




```
[ pLine(Q, cm)→ ]
```

"Range" Notation: $X = pR(xmin, xmax, nx)$ $Y = pR(ymin, ymax, ny)$

$f(x, y) := \begin{bmatrix} y \\ x^2 - x - 2 \cdot y \end{bmatrix}$

$X := pR(-3, 3, 20)$

$Y := pR(-3, 3, 20)$

$G := pGrid(\text{"f"}, X, Y)$

$Q := pQuiver(G, X, Y)$

$cm := pClr\left(\overrightarrow{\text{norme}(G)}, CM\right)$

$xo := pR(-3, 3, 6)$

$yo := pR(-3, 3, 6)$

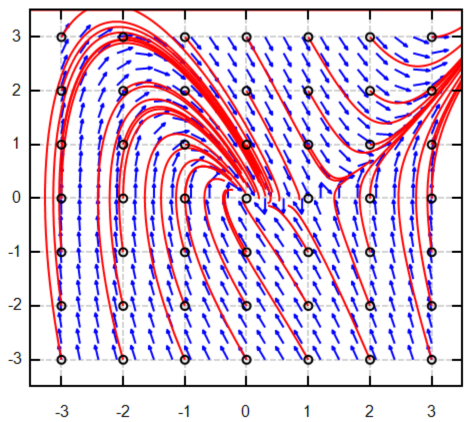
$RK(x, y) := pRK(\text{"f"}, x, y, 2)$

$IC := pGrid(\text{"RK"}, xo, yo)$

$O := \overrightarrow{\text{augment}(\text{row}(IC, 1), \text{"o"}, 4)}$

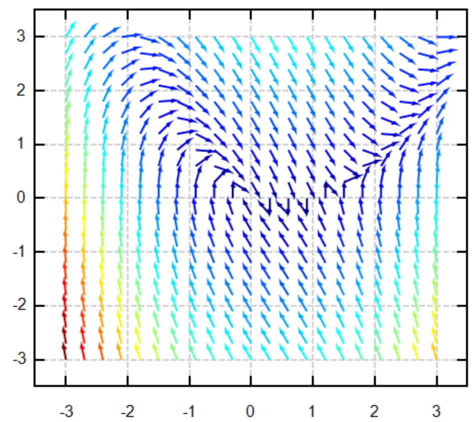
$pIC := \begin{cases} pCycleC(Q) \\ pCycleC(IC) \\ pCycleC(O) \end{cases}$

Ingegral Curves & monochrome VF



pIC

Map Colored Vector Field



$\left[\overrightarrow{pLine(Q, cm)}\right]$

Potential and Gradient example

$f(x, y) := x \cdot y + x \cdot \cos(y)$

$g(x, y) := \begin{bmatrix} \frac{d}{dx} f(x, y) & \frac{d}{dy} f(x, y) \end{bmatrix}^T$

$\left[B := \begin{bmatrix} -6 & 6 \\ -\pi & \pi \end{bmatrix} \quad N := \begin{bmatrix} 9 \\ 6 \end{bmatrix} \right]$

$Q := pQuiver(\text{"g"}, B, 3 \cdot N)$

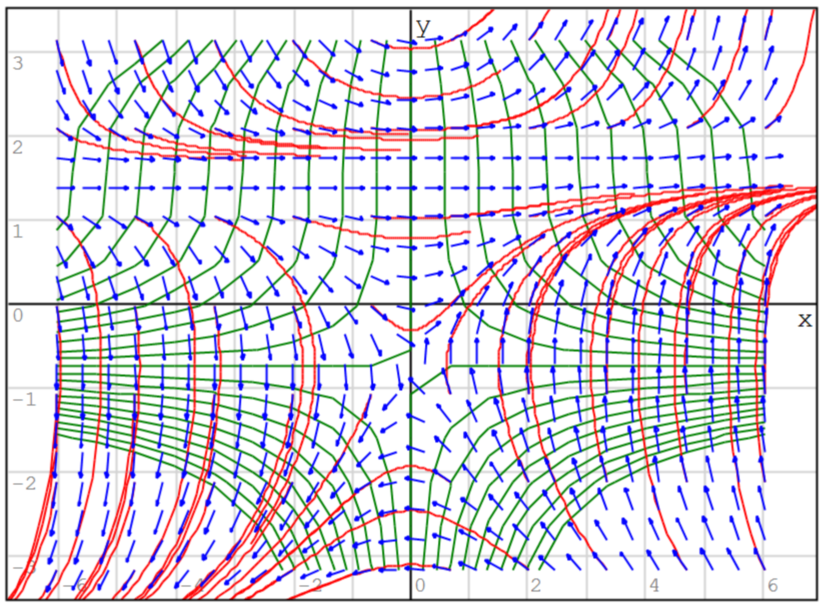
$RK(x, y) := pRK(\text{"g"}, x, y, 2)$

$IC := pGrid(\text{"RK"}, B, N)$

$\lambda := pR(-9, 9, 20)$

$L := pContour(\text{"f"}, B, 4 \cdot N, \lambda)$

$Plot := \begin{cases} pCycleC(Q) \\ pCycleC(IC) \\ pCycleC(L) \end{cases}$



Plot

Electric Field

$U = Pontetial$

$E = Field$

$k := 9$

$Q := \begin{bmatrix} 1 & 3 & -2 & -1 \end{bmatrix}$

$P := \begin{bmatrix} 4 & -3 & 1 & -4 \\ -3 & -2 & 2 & 0 \end{bmatrix}^T$

Constant Charges

Place Points

$B := \begin{bmatrix} -5 & 5 \\ -5 & 5 \end{bmatrix}$

$N := \begin{bmatrix} 6 & 6 \end{bmatrix}$

Box Plot

Steps

$$U(x,y) := \sum_{n=1}^{4} \frac{k \cdot Q_n}{\sqrt{\left(x - P_{n\,1}\right)^2 + \left(y - P_{n\,2}\right)^2}}$$

$h := 0.0000001$

$$E(x,y) := \begin{array}{l} U := U(x,y) \\ E := \begin{bmatrix} U(x+h, y) - U \\ U(x, y+h) - U \end{bmatrix} \\ \dfrac{-E}{\text{norme}(E)} \end{array}$$

$G := pGrid(\text{"E"}, B, 4 \cdot N)$

$Q := pQuiver(G, B, 4 \cdot N)$

$RK(x,y) := pRK(\text{"E"}, x, y, 4)$

$IC := pGrid(\text{"RK"}, B, N)$

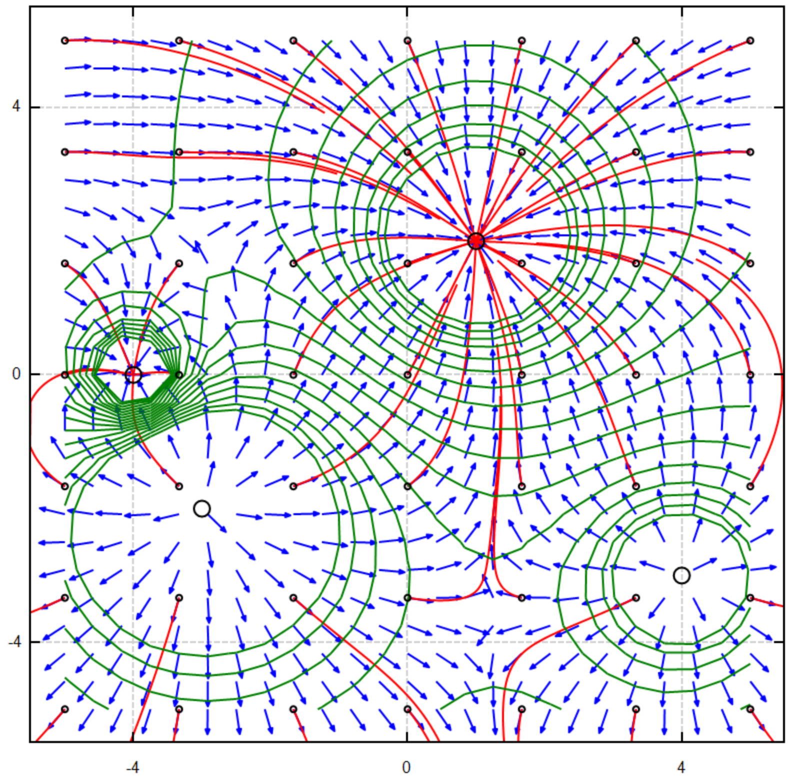
$O := \text{eval}\left(\overrightarrow{\text{augment}(\text{row}(IC, 1), \text{"o"}, 3)}\right)$

$\lambda := pR(-k, k, 15)$

$L := pContour(\text{"U"}, B, 8 \cdot N, \lambda)$

$$Plot := \begin{cases} pCycleC(Q) \\ pCycleC(IC) \\ pCycleC(L) \\ \text{mat2sys}_1(O) \\ \text{augment}(P, \text{"o"}) \end{cases}$$

Note: E isn't the field, it is divided by it's norme for stabilizing the RK method



Plot

The integral curves (red) are the paths that positive test charges placed in the field would take, and they are collinear with the vector field (blue) and perpendicular to the potential contour lines (green).

pZ

Plotting Complex Functions

$pZ(\text{"f"}, B, N, cm)$ plots the argument of f(z) in the box B with N points with the colormap cm

$cm := pCMap(\text{"Jet"}, 200, 1)$

$pZ(\text{"f"}, B, N)$ plots the complex map of f(z) in the box B with N points

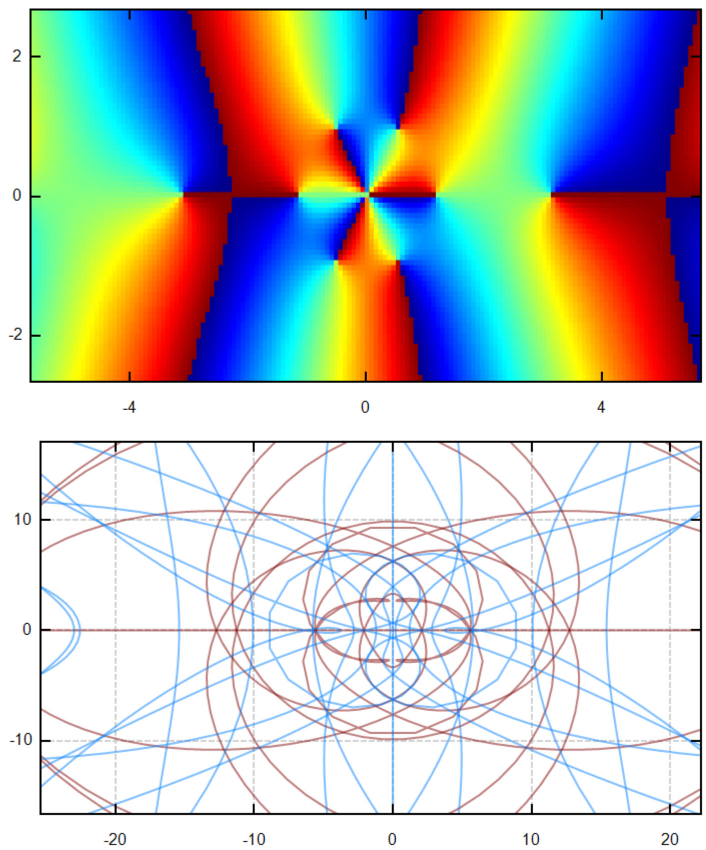
$B := \begin{bmatrix} -6 & 6 \\ -3 & 3 \end{bmatrix} = \begin{bmatrix} x1 & x2 \\ y1 & y2 \end{bmatrix}$

$N := \begin{bmatrix} 160 \\ 80 \end{bmatrix} = \begin{bmatrix} nx \\ ny \end{bmatrix}$

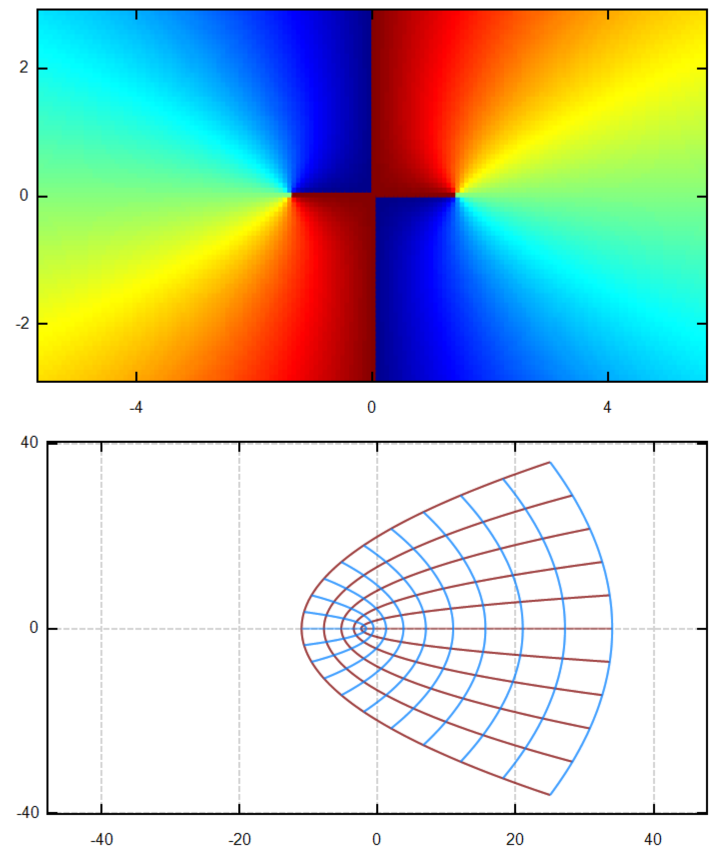
$B' := B \qquad N' := \begin{bmatrix} 20 \\ 10 \end{bmatrix}$

Zeros counterclockwise color change. Also, the polynomial degree cycle the colors.

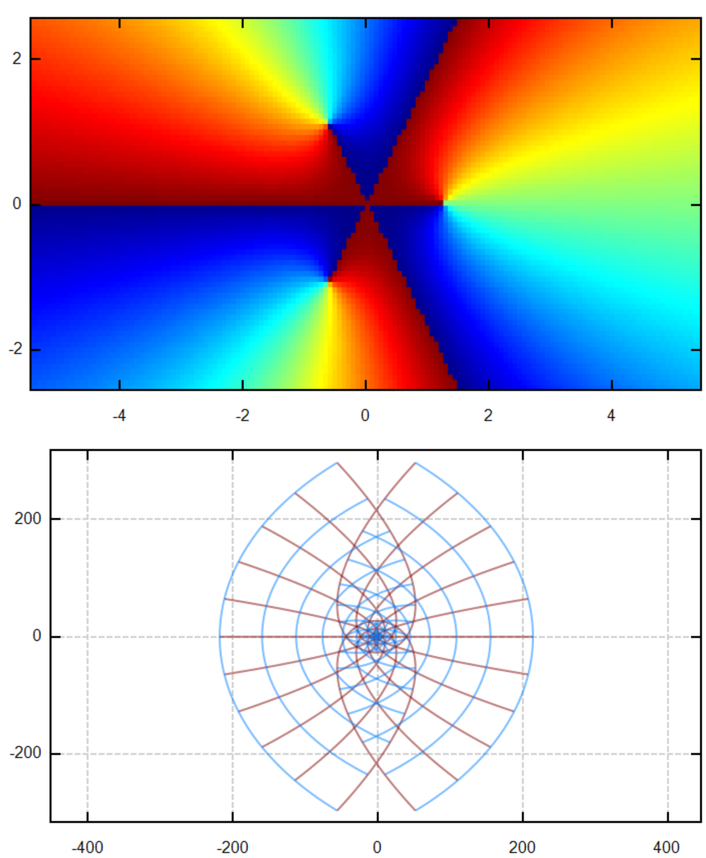
$f_1(z) := z^2 \cdot \sin(z) - \frac{2}{z^3}$



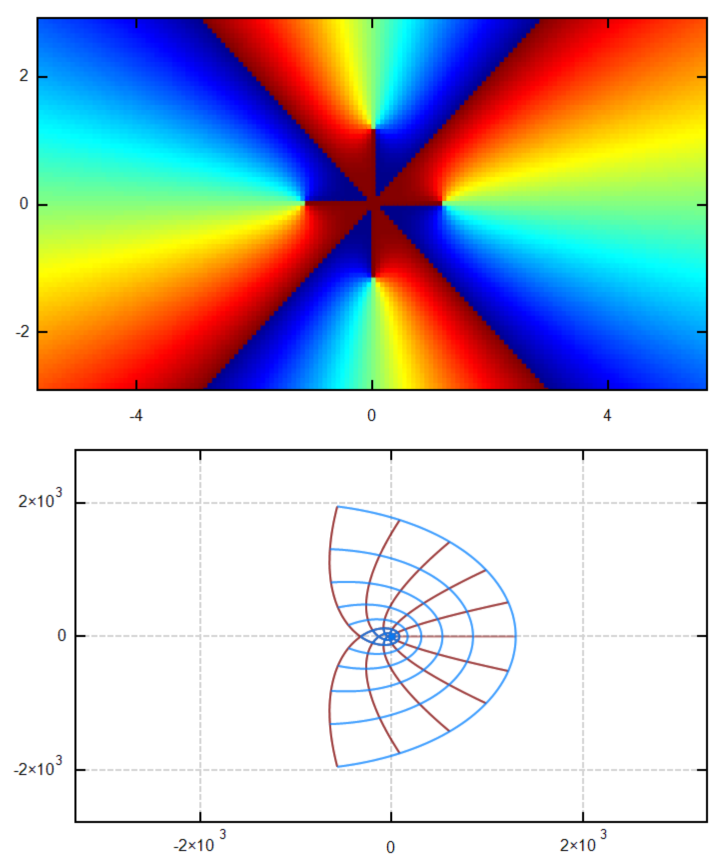
$f_2(z) := z^2 - 2$



$f_1(z) := z^3 - 2$



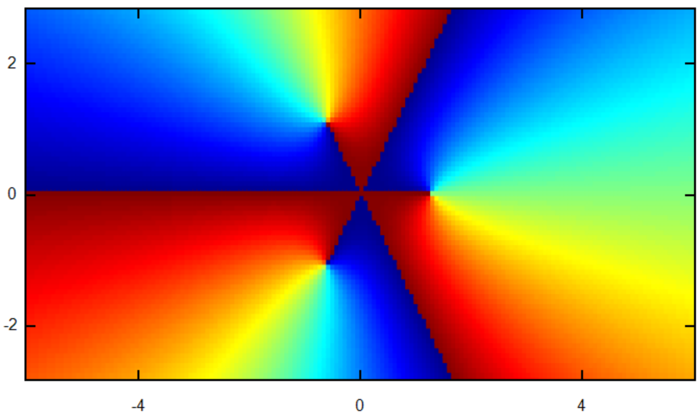
$f_2(z) := z^4 - 2$

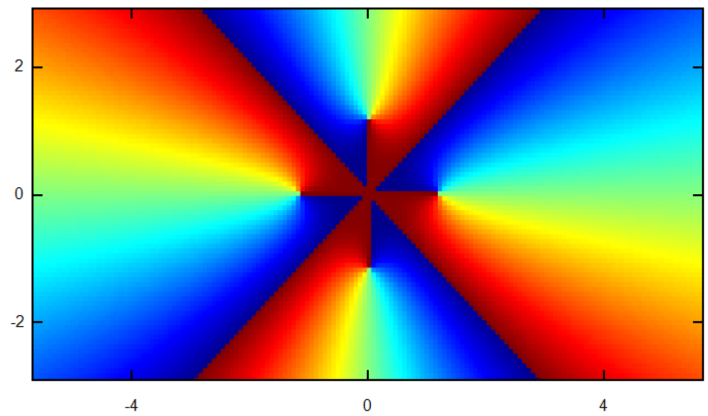


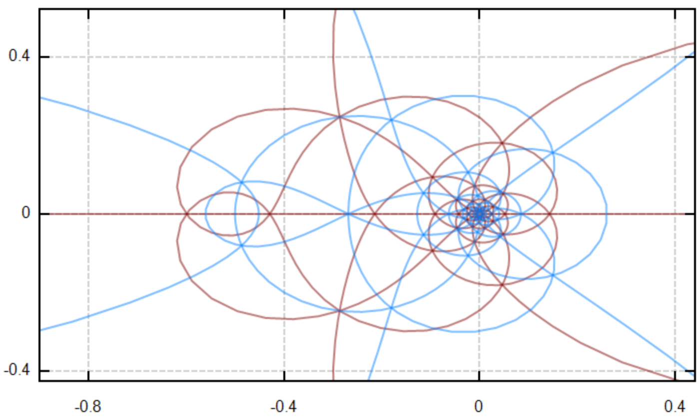
Poles clockwise color change.

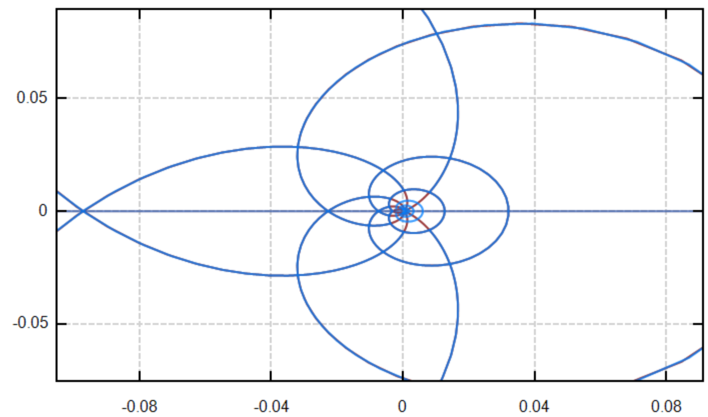
$$f_1(z) := \frac{1}{z^3 - 2}$$

$$f_2(z) := \frac{1}{z^4 - 2}$$



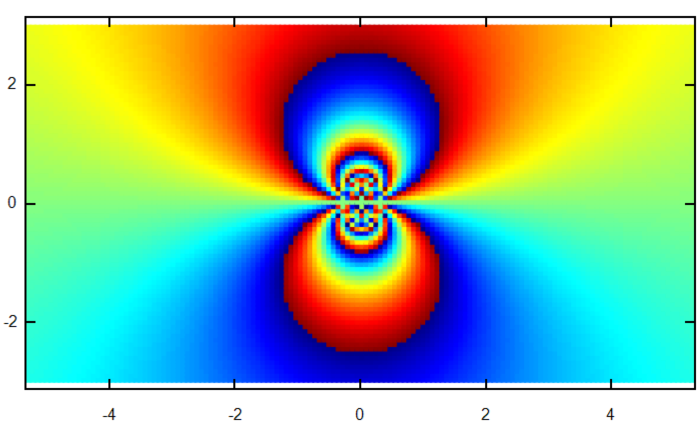


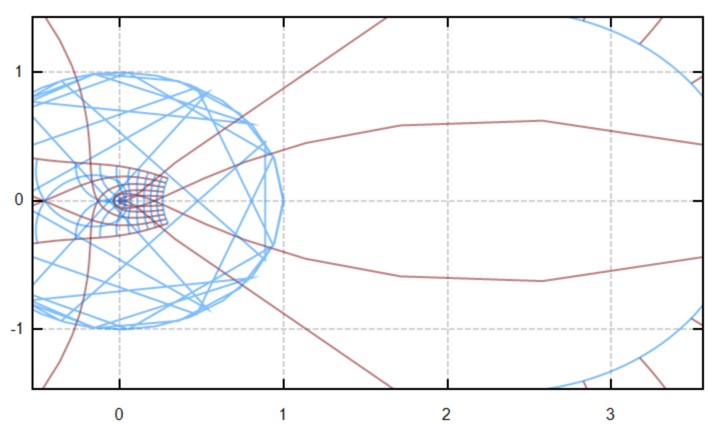




Essential dicontinuity infinite color change.

$$f_1(z) := \mathbf{e}^{-\frac{8}{z}}$$

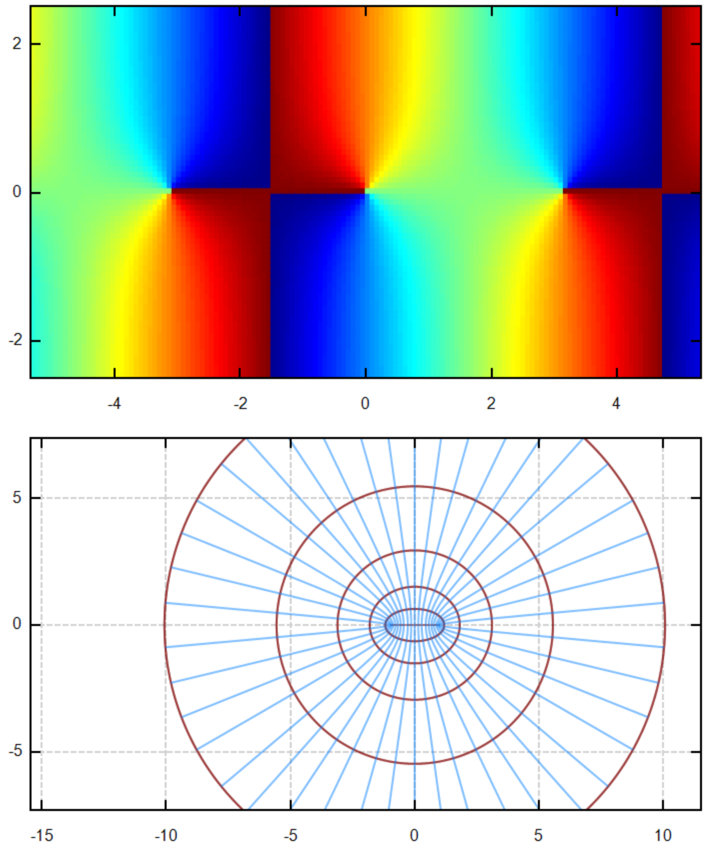


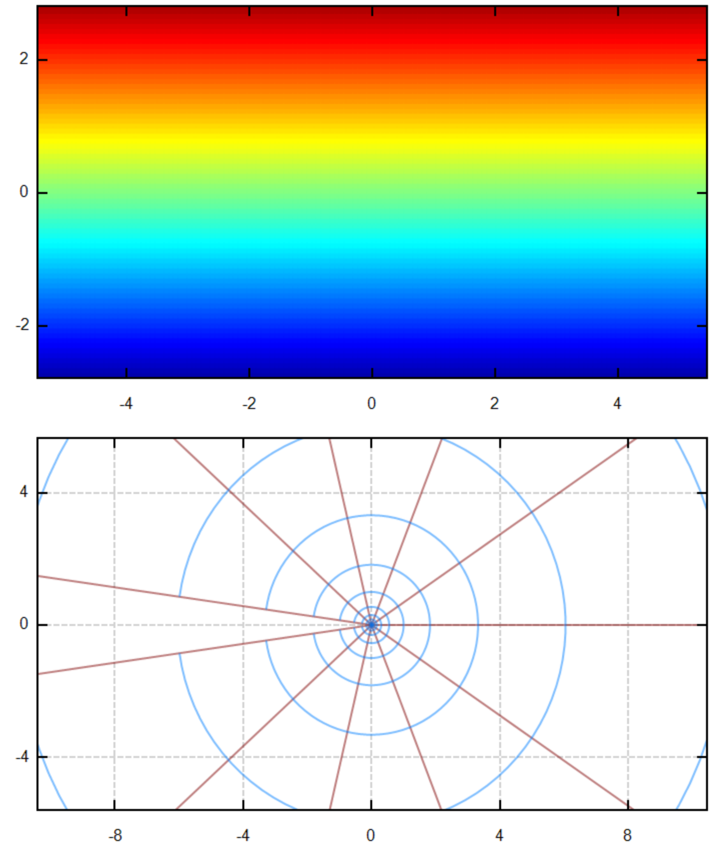


Periodicity

$f_1(z) := \sin(z)$ period 2π (horizontal)

$f_2(z) := \mathbf{e}^{z}$ period 2πi (veritcal)

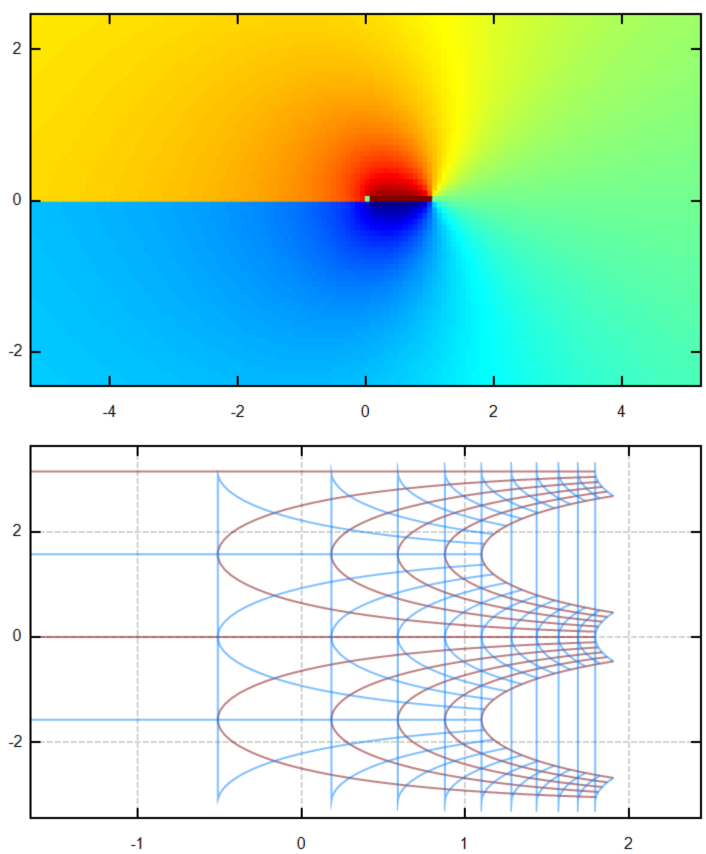


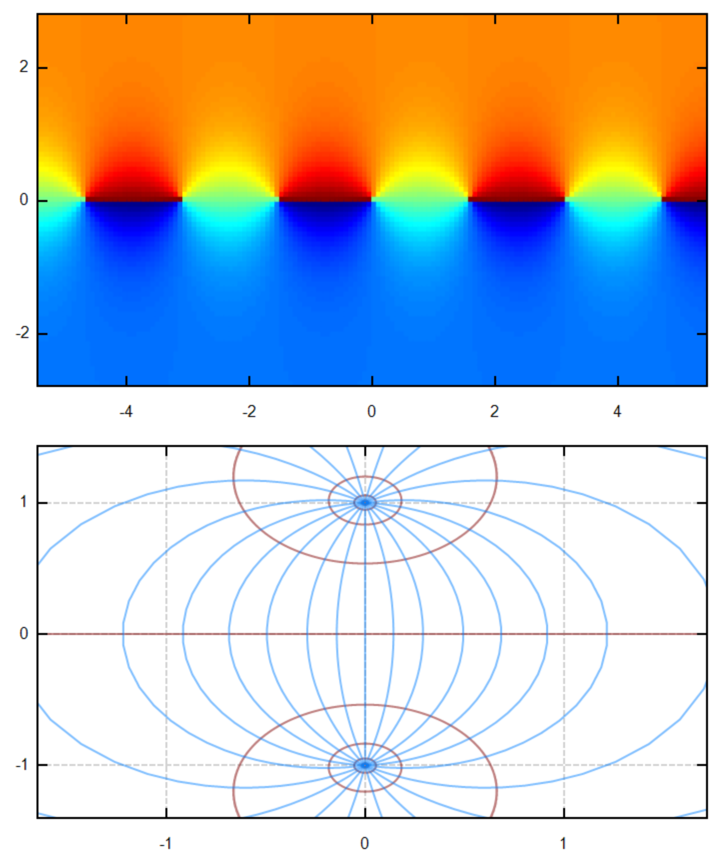


Gallery

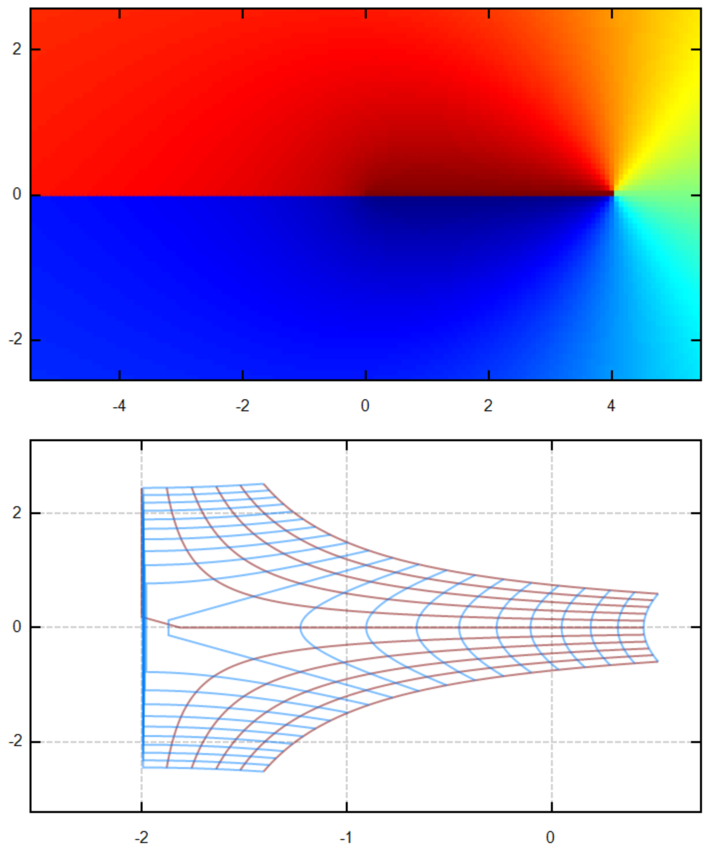
$f_1(z) := \ln(z)$

$f_2(z) := \tan(z)$

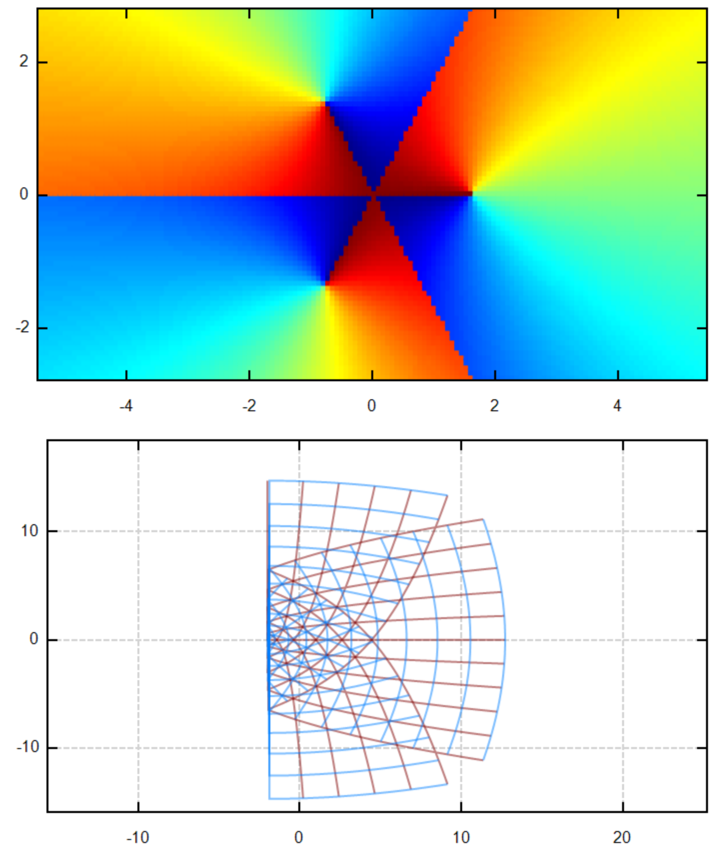




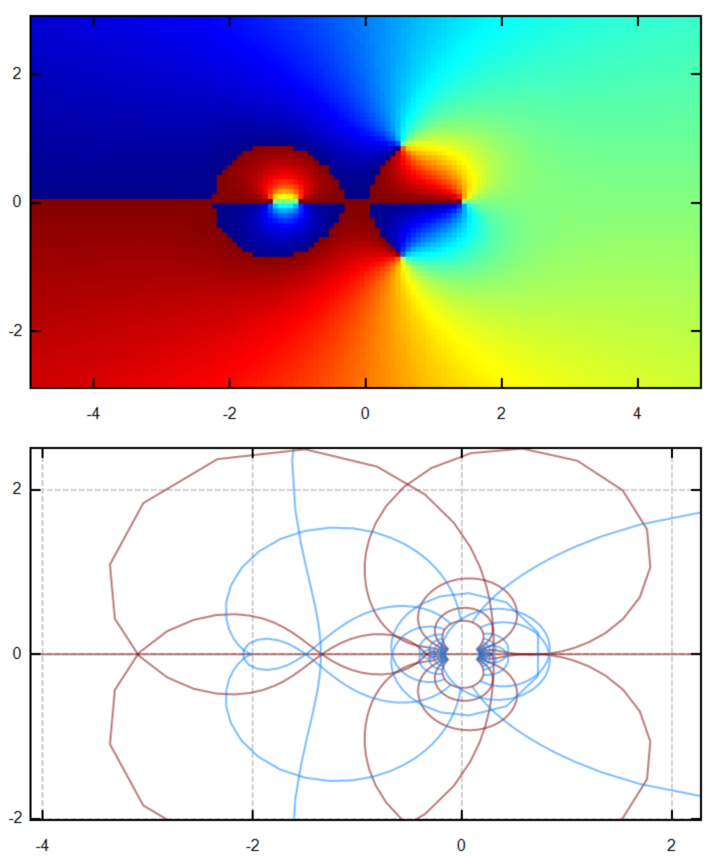

$f_1(z) := \sqrt{z} - 2$



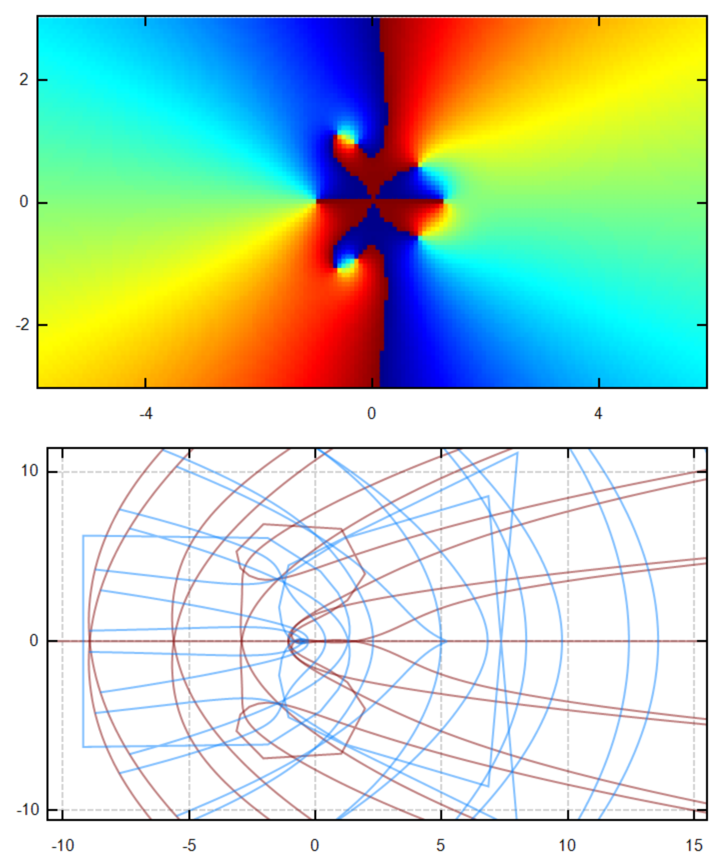
$f_2(z) := \sqrt{z^3} - 2$



$f_1(z) := \dfrac{z^2 - 2}{z^3 + 1}$



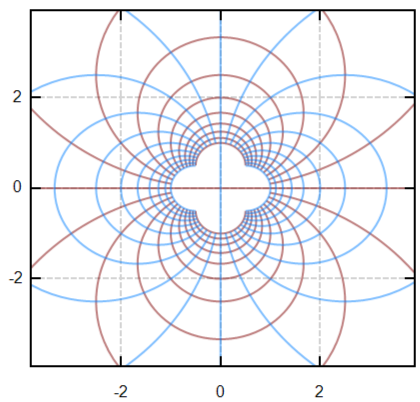
$f_2(z) := \dfrac{z^5 + 1}{z^3 - 2}$



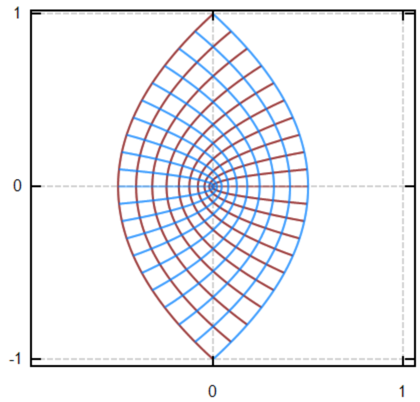
Other examples

$B := \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}$ $\qquad N := 2 \cdot \begin{bmatrix} 10 \\ 10 \end{bmatrix}$

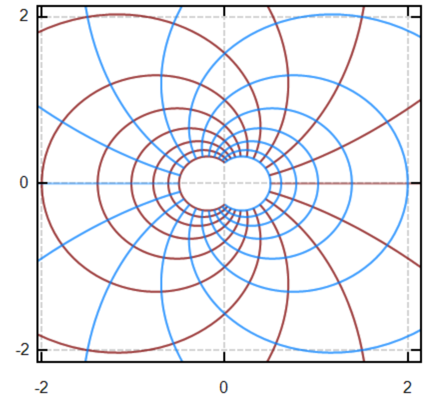
$f_1(z) := \frac{1}{z}$



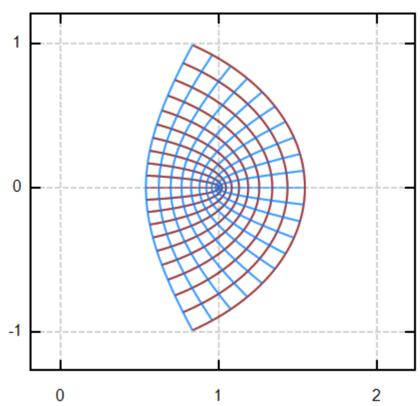
$f_2(z) := \frac{z^2}{2}$



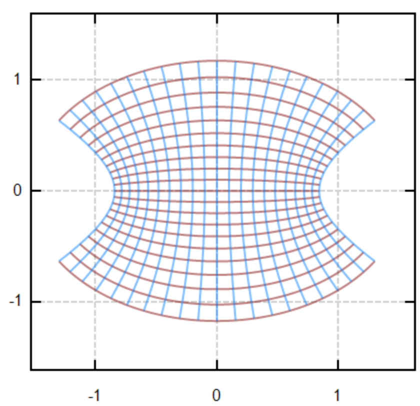
$f_3(z) := \frac{1}{2 \cdot z^2}$



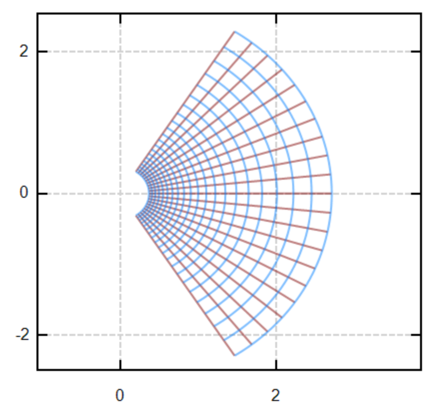
$f_1(z) := \cos(z)$



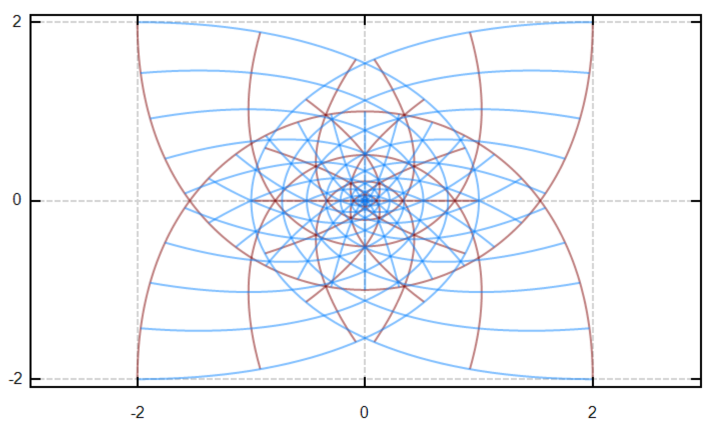
$f_2(z) := \sin(z)$



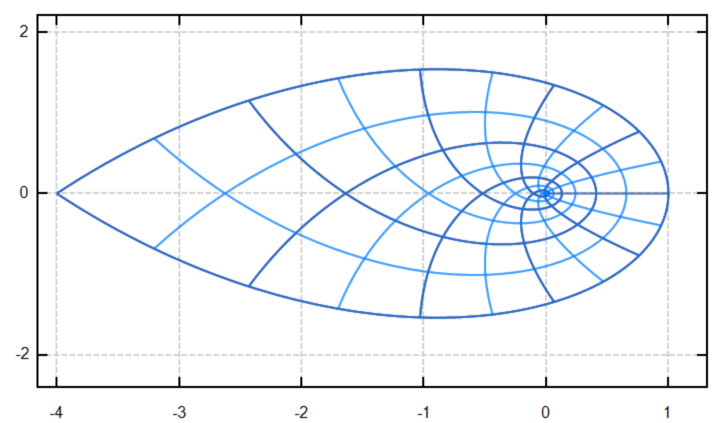
$f_3(z) := \mathbf{e}^z$



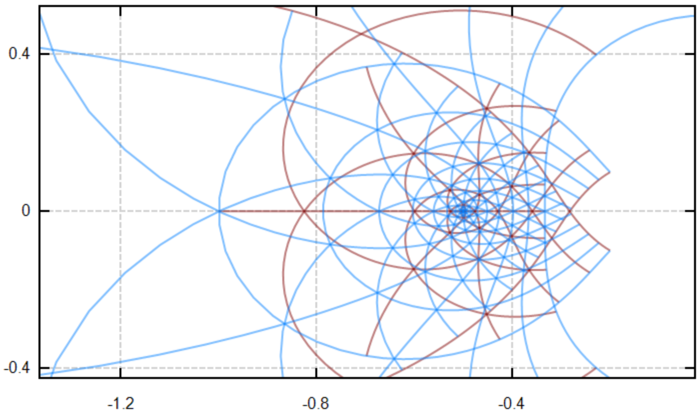
$f_1(z) := z^3$



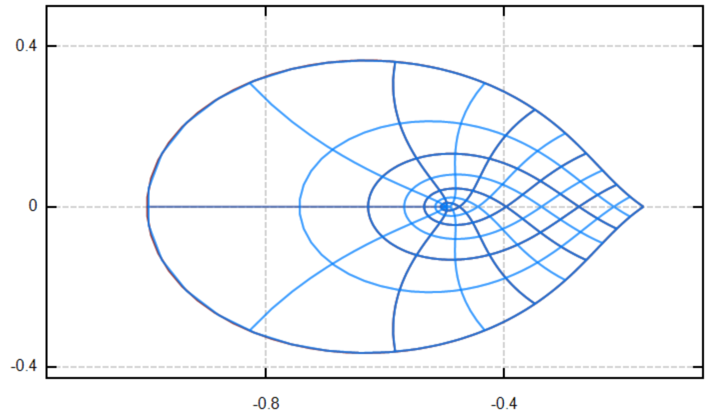
$f_2(z) := z^4$



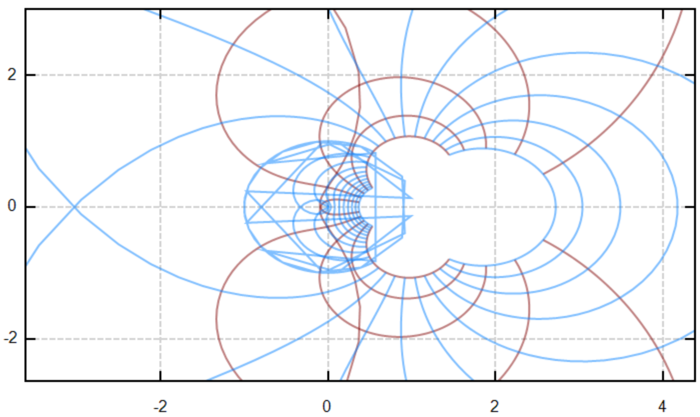
$f_1(z) := \frac{\quad}{z^3 - 2}$



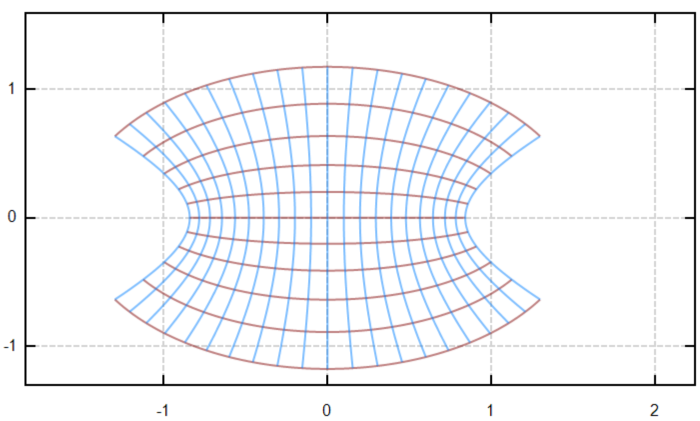
$f_2(z) := \frac{\quad}{z^4 - 2}$



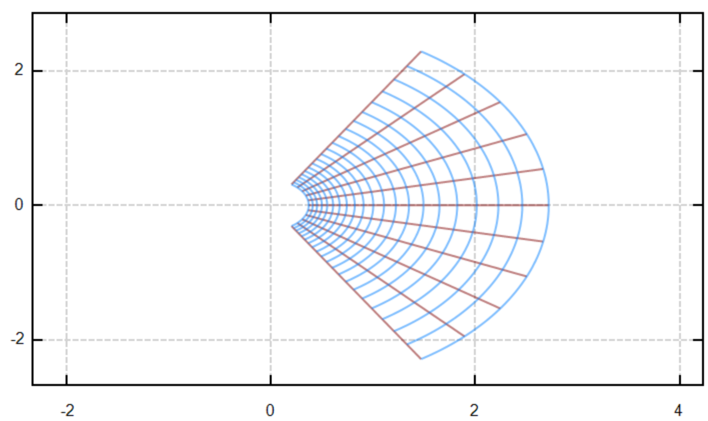
$f_1(z) := e^{-\frac{1}{z}}$



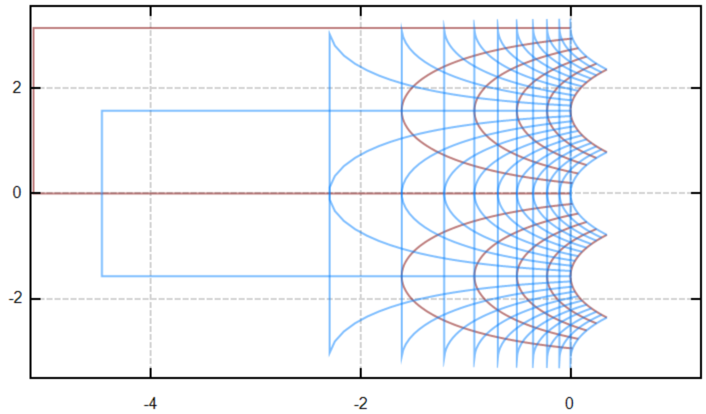
$f_1(z) := \sin(z)$



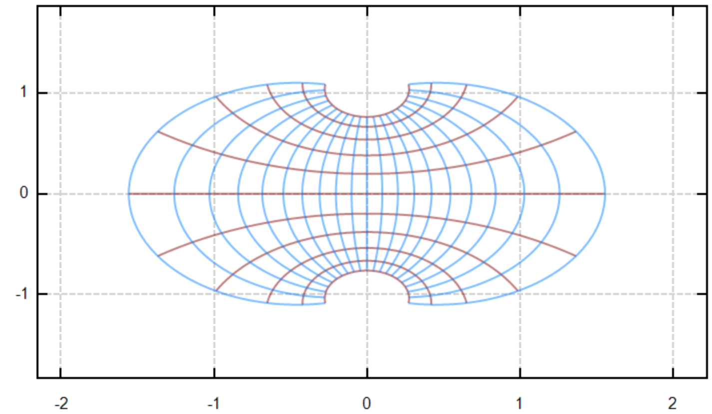
$f_2(z) := e^{z}$



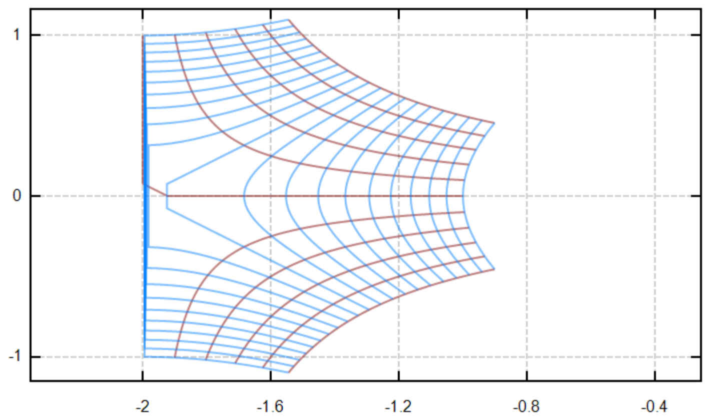
$f_1(z) := \ln(z)$



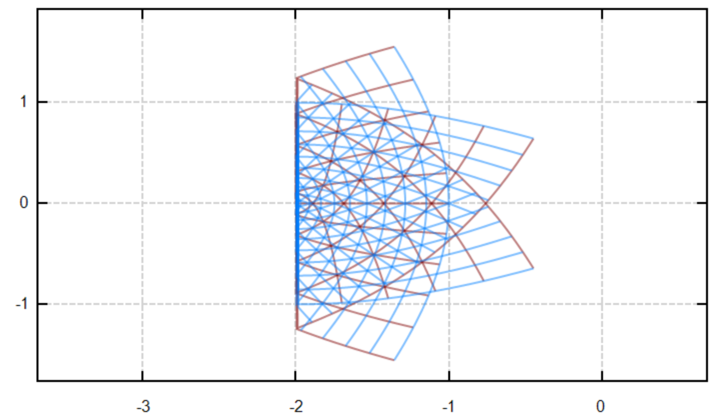
$f_2(z) := \tan(z)$



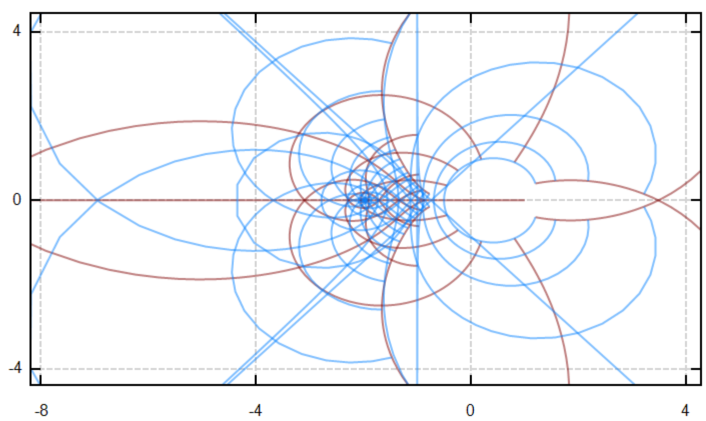
$f_1(z) := \sqrt{z} - 2$



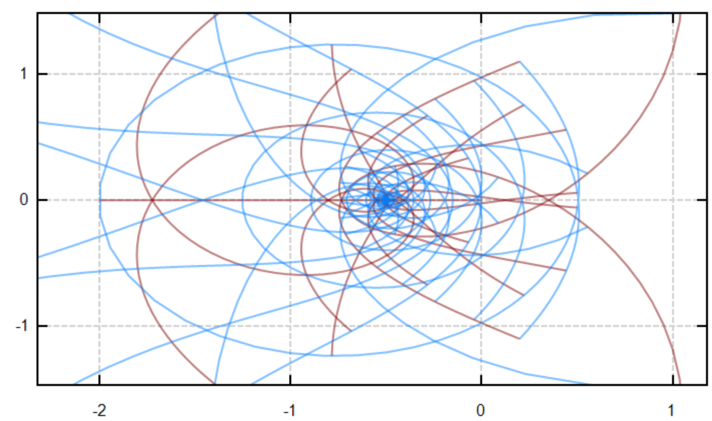
$f_2(z) := \sqrt{z^3} - 2$



$f_1(z) := \frac{z^2 - 2}{z^3 + 1}$



$f_2(z) := \frac{z^5 + 1}{z^3 - 2}$



pD3

Third degree ODE Plot

$\gamma := pView(120°, 15°)$ $AbsTol := 10^{-3}$ $RelTol := 10^{-3}$

$a := 3$ $b := 2.7$ $c := 1.7$ $d := 2$ $f := 9$ $t_{max} := 60$

$$D(t,u) := \left\| \begin{array}{l} [x\ y\ z] := u^T \\ \begin{bmatrix} y - a \cdot x + b \cdot y \cdot z \\ c \cdot y - x \cdot z + z \\ d \cdot x \cdot y - f \cdot z \end{bmatrix} \end{array} \right.$$

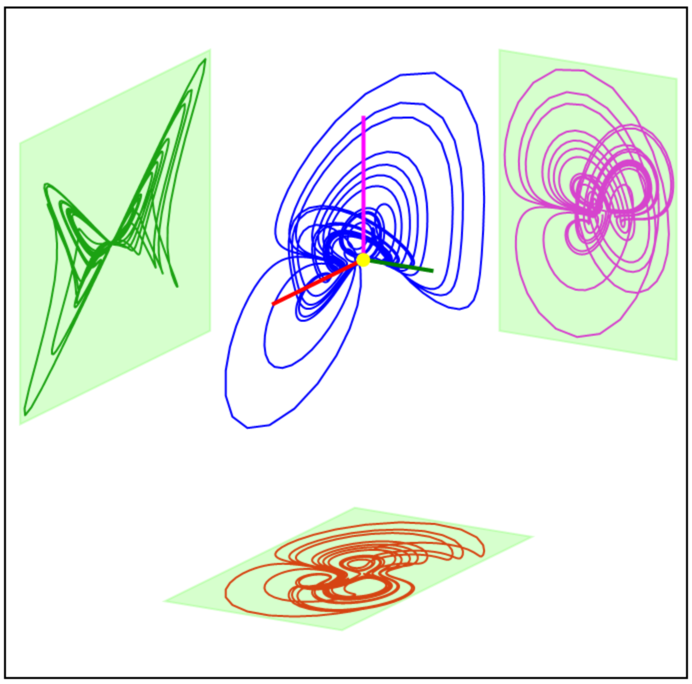
$$Dadras := \text{Rkadapt}\left([0.1\ 0.03\ 0]^T, 0, t_{max}, 4000, D\right)$$

$a := 0.95$ $b := 0.7$ $c := 0.6$ $d := 3.5$ $f := 0.25$ $g := 0.1$ $t_{max} := 100$

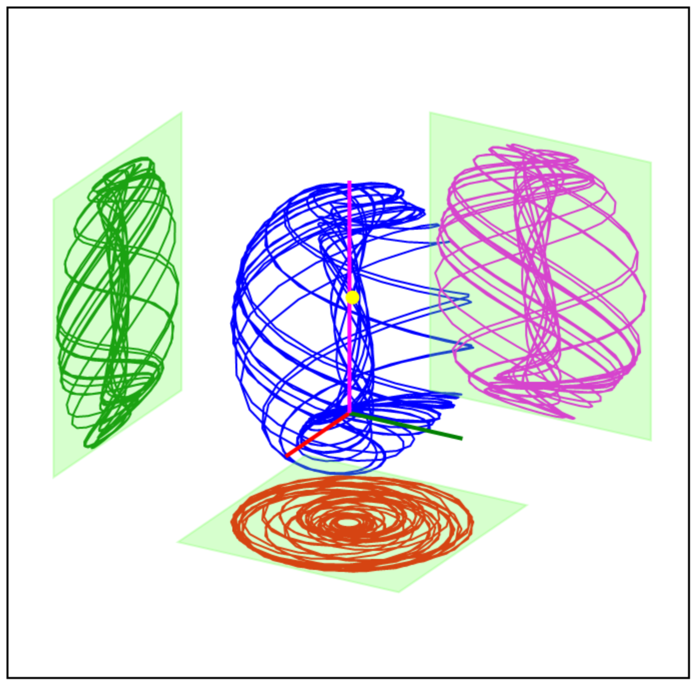
$$\left[\begin{array}{ll} x'(t) = (z(t) - b) \cdot x(t) - d \cdot y(t) & x(0) = 0.1 \\ y'(t) = d \cdot x(t) + (z(t) - b) \cdot y(t) & y(0) = 0.1 \\ z'(t) = c + a \cdot z(t) - \frac{z(t)^3}{3} - \left(x(t)^2 + y(t)^2\right) \cdot (1 + f \cdot z(t)) + g \cdot z(t) \cdot x(t)^3 & z(0) = 1 \end{array}\right.$$

$$Aizawa := \text{Rkadapt}\left(\begin{Bmatrix} x(t) \\ y(t) \\ z(t) \end{Bmatrix}, t_{max}, 1000\right)$$

$P_1 := pD3(Dadras, \gamma)$ $P_2 := pD3(Aizawa, \gamma)$



P_1



P_2

Clear$(a, b, c, d, f, g) = 1$

Mandelbrot set

Mandelbrot set

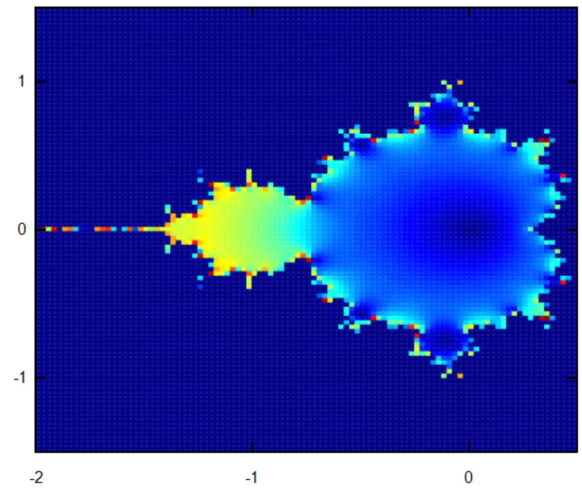
$n := 15$

$Mandelbrot(x, y) := \left| \begin{array}{l} [\, k := 0 \;\; z := 0 \,] \\ \text{while } (|z| < 2) \wedge (k < n) \\ \quad [\, k := k + 1 \;\; z := z^2 + x + i \cdot y \,] \\ |z| \cdot (|z| < 2) \end{array} \right.$

$\left[B := \begin{bmatrix} -2 & 0.5 \\ -1.5 & 1.5 \end{bmatrix} \;\; N := \begin{bmatrix} 100 \\ 100 \end{bmatrix} \right]$

$cm := pCMap(\text{"Jet"}, 200, 0.9)$

$Plot := pFillContour(Mandelbrot, B, N, cm)$



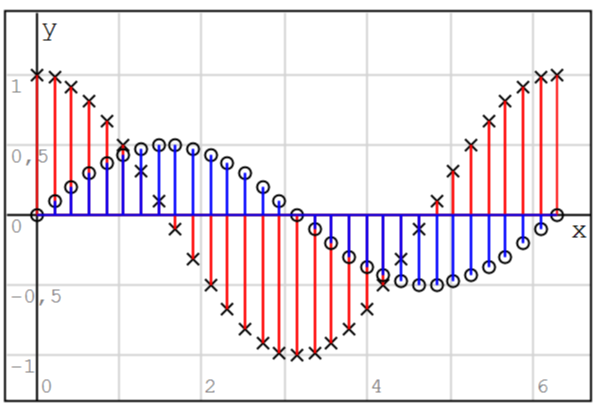
pStem

Stem plot

$X := pR(0, 2 \cdot \pi, 30)$

Calling pStem(f,X)

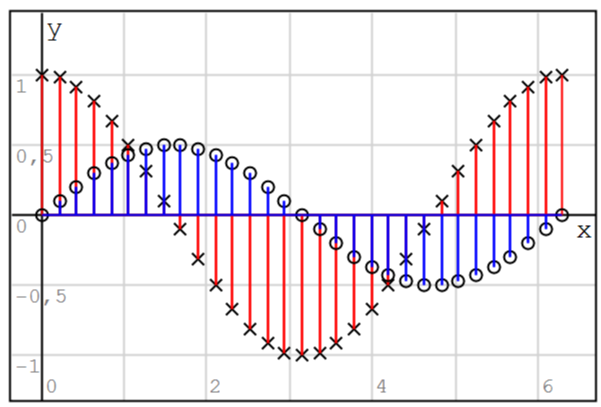
$f_1(x) := 0.5 \cdot \sin(x) \qquad f_2(x) := \cos(x)$



$\left\{ \begin{array}{l} pStem(f_1, X) \\ pStem(f_2, X, \text{"x"}) \end{array} \right.$

Calling pStem(X,Y)

$Y_1 := \overrightarrow{f_1(X)} \qquad Y_2 := \overrightarrow{f_2(X)}$



$\left\{ \begin{array}{l} pStem(X, Y_1) \\ pStem(X, Y_2, \text{"x"}) \end{array} \right.$

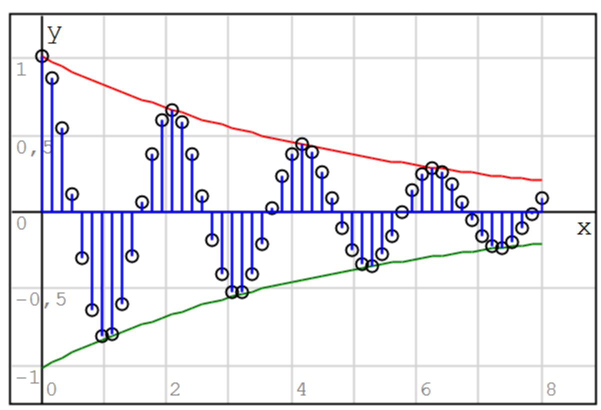
Another example

$X_3 := pR(0, 8, 50)$

$A := \overrightarrow{e^{-0.2 \cdot X_3}}$

$Y_3 := \overrightarrow{A \cdot \cos(3 \cdot X_3)}$

$Plot := \left\{ \begin{array}{l} pStem(X_3, Y_3) \\ augment(X_3, A) \\ augment(X_3, -A) \end{array} \right.$



Plot

⊟— Azimut & Elevation animation

Az&El Animation

$txt(ae, t) := \text{augment}\left(-3, -4, \text{concat}\left(ae, \text{"="}, \text{var2str}\left(\frac{t}{°}, 0\right)\right)\right)$

$\left[B := 3 \cdot \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix} \quad N := 2 \cdot \begin{bmatrix} 20 \\ 20 \end{bmatrix}\right]$

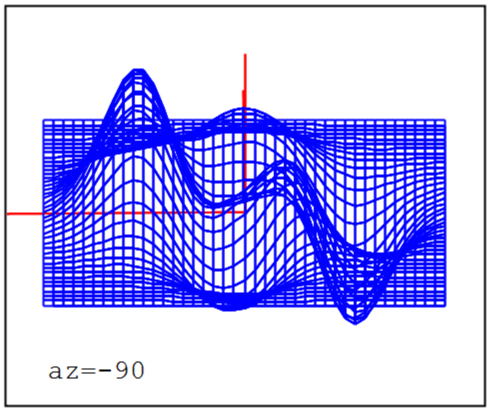
$S := pMesh(\text{"peaks"}, B, N)$

$t_a := pR(-180°, 180°, 60)$

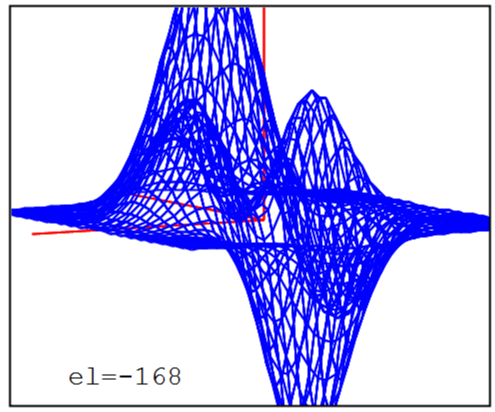
$\gamma_a(t) := pView2(t, 60°)$

$t_e := pR(-180°, 180°, 60)$

$\gamma_e(t) := pView2(30°, t)$



$S \cdot \gamma_a(t)$
$pAxis(4, 4, 9) \cdot \gamma_a(t)$
$txt(\text{"az"}, t)$



$S \cdot \gamma_e(t)$
$pAxis(4, 4, 9) \cdot \gamma_e(t)$
$txt(\text{"el"}, t)$

⊟— Examples of view

Examples of view

$B := 3 \cdot \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}$

$N := 2 \cdot \begin{bmatrix} 10 \\ 10 \end{bmatrix}$

$S := pMesh(peaks, B, N)$

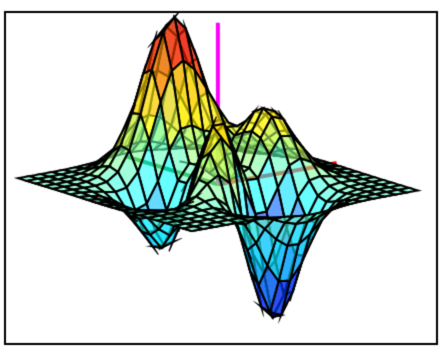
$GM := pCMap(\text{"black"})$

$GS := pCMap(\text{"Jet"}, 32, 0.6)$

$view(az, el, s) := pShow(S, s \cdot N, pView2(az, el), GM, GS)$

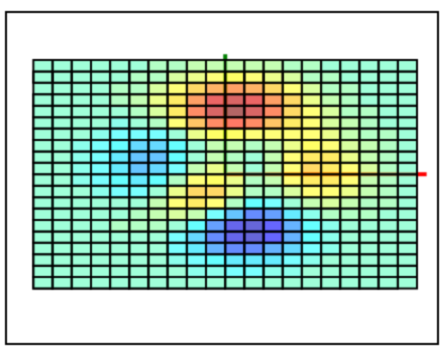
Change the sign of N for reverse the mesh if it is necessary.

Default Matlab view



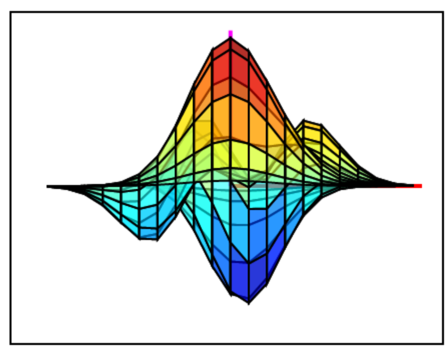
$view(-37.5°, 30°, -1)$

2D view



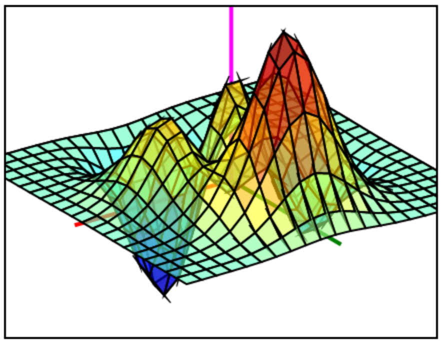
$view(0°, 90°, 1)$

First column view



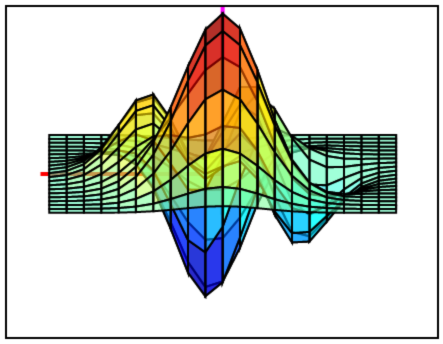
$view(0°, 0°, 1)$

Fridel usual view



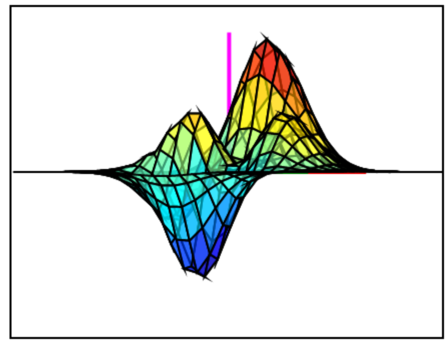
view (145 °, 48 °, 1)

For az = 180 is behind the matrix



pSort := 0
view (180 °, 30 °, 1)

Rotated first column



view (30 °, 0 °, 1)

Color mapping Examples

pCMap is for creating color maps. It take as arguments a SMath color string, or "Jet", "R", "G" and "B". or an array [r g b] with one of the r, g or b equals zero.

The other arguments are the number of the colors and the transparency as a number between 0 and 1.

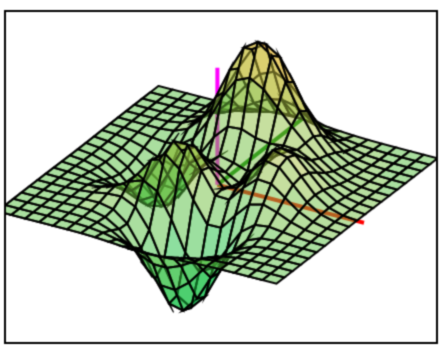
$B := 3 \cdot \begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}$ $N := \begin{bmatrix} 20 \\ 20 \end{bmatrix}$

$Y_2 := pView2(30°, 60°)$
$S := pMesh(peaks, B, N)$

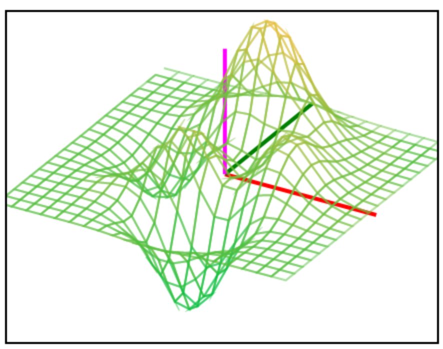
pShowAxis := 1 This shows the axis.

G := pCMap([0 192 64], 10, 0.5) makes a colormap looking at the zero value from $rgb([0\ 192\ 64], 0.5) = G_1$

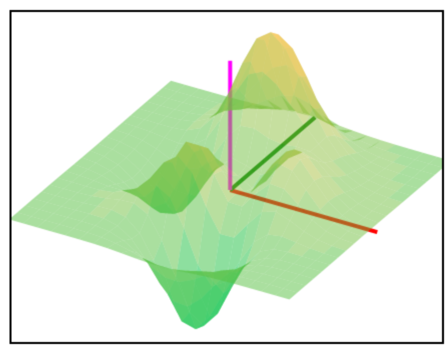
to $rgb([255\ 192\ 64], 0.5) = G_{10}$



pShow (S, N, Y_2, "black", G)



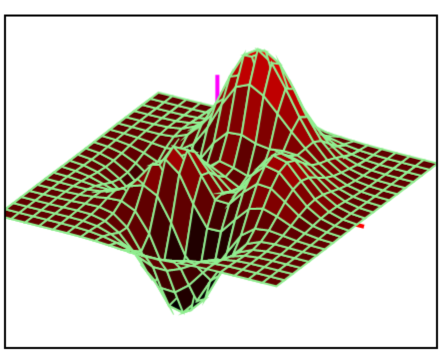
pShow (S, N, Y_2, G, 0)



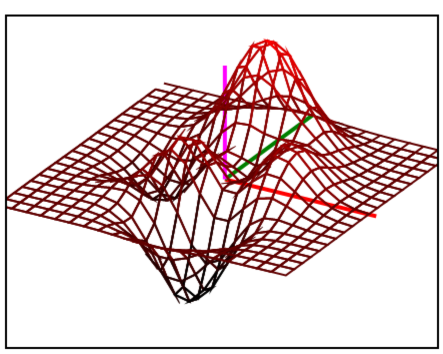
pShow (S, N, Y_2, 0, G)

G := pCMap ("R", 9, 1) Makes a colormap with a red scale. Similar for "G" and "B"

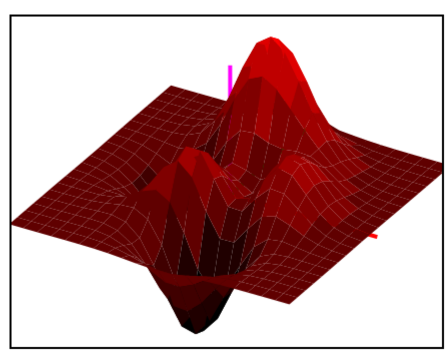
$pCMap("B", 9, 0)^T = [0\ 32\ 64\ 96\ 128\ 159\ 191\ 223\ 255]$



pShow (S, N, Y_2, "lightgreen", G)

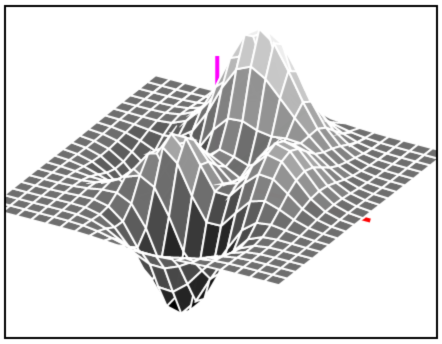


pShow (S, N, Y_2, G, 0)

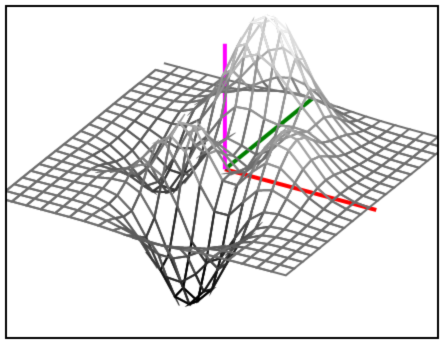


pShow (S, N, Y_2, 0, G)

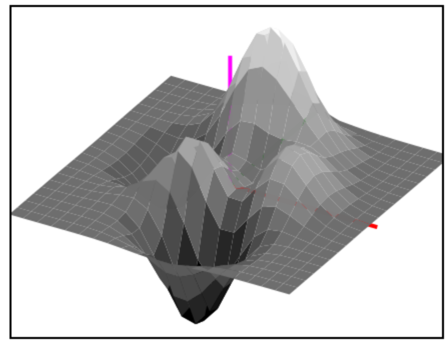
$G := pCMap("GS", 15, 1)$ Makes a colormap with 15 gray values $\text{length}(G) = 15$



$pShow(S, N, Y_2, \text{"white"}, G)$

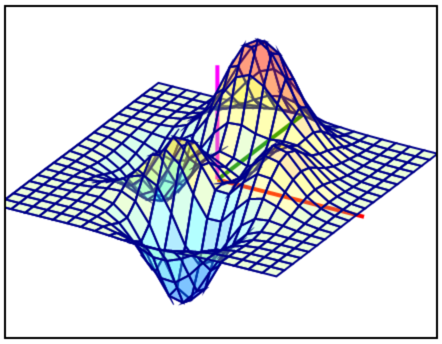


$pShow(S, N, Y_2, G, 0)$

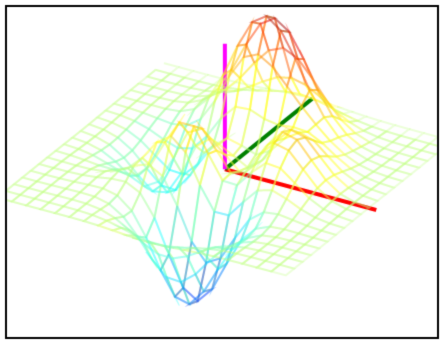


$pShow(S, N, Y_2, 0, G)$

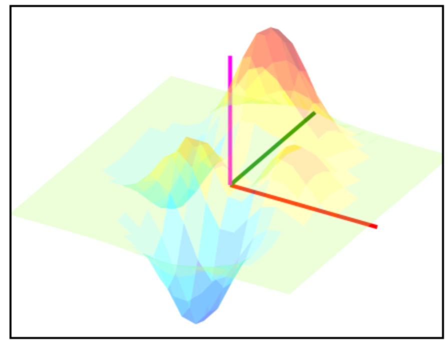
$G := pCMap("Jet", 15, 0.3)$ The Jet color map, from NASA.



$pShow(S, N, Y_2, \text{"darkblue"}, G)$



$pShow(S, N, Y_2, G, 0)$



$pShow(S, N, Y_2, 0, G)$

Alvaro