Mathematical background

Position vector

In[1]:=
```
rr[x_, y_, z_] := {x, y, z}
```

Diffraction theory

Spherical wave (pressure) at rr0

In[38]:=
```
rr0 = rr[x0, y0, z0]
```

$$psph = \frac{Exp[I\,k\,Norm\,[rr[x, y, z] - rr0]]}{Norm\,[rr[x, y, z] - rr0]}$$

Out[38]= {x0, y0, z0}

Out[39]=
$$\frac{e^{i\,k\,\sqrt{Abs[x-x0]^2+Abs[y-y0]^2+Abs[z-z0]^2}}}{\sqrt{Abs[x-x0]^2+Abs[y-y0]^2+Abs[z-z0]^2}}$$

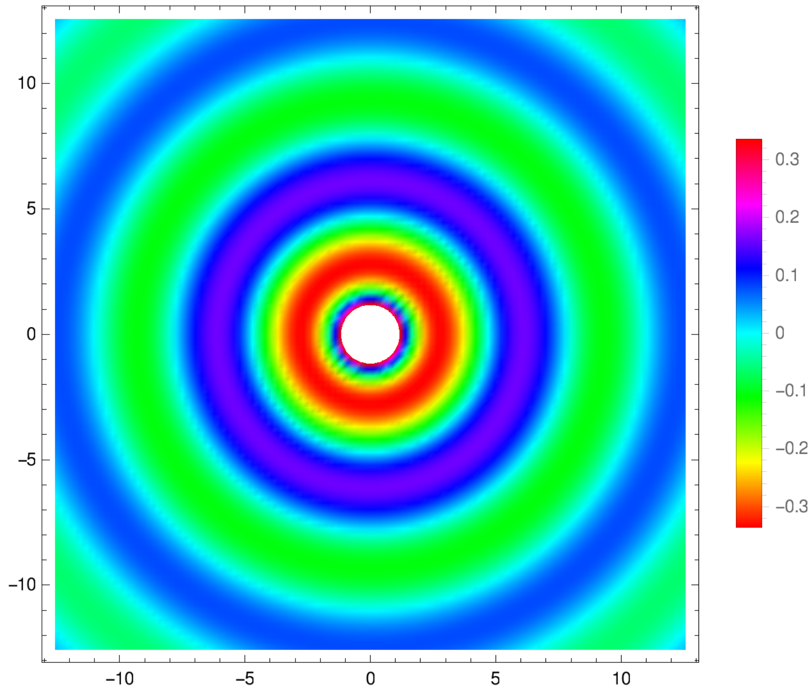
Source at the origin of the coordinate system, with k =2π/λ =1

In[50]:=
```
psph0 = psph /. {x0 → 0, y0 → 0, z0 → 0, z → 0, k → 1}
```

Out[50]=
$$\frac{e^{i\,\sqrt{Abs[x]^2+Abs[y]^2}}}{\sqrt{Abs[x]^2+Abs[y]^2}}$$

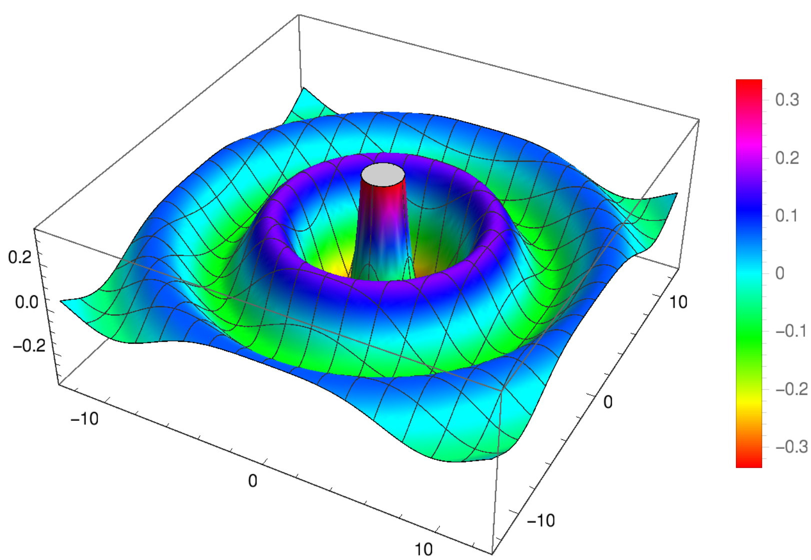
In[51]:=
```
DensityPlot[Re[psph0], {x, -4 π, 4 π}, {y, -4 π, 4 π}, PlotRange → Automatic ,
  PlotLegends -> Automatic , ColorFunction → Hue, PlotPoints → 100]
```

Out[51]=



In[52]:=
```
Plot3D[Re[psph0], {x, -4 π, 4 π}, {y, -4 π, 4 π}, PlotRange → Automatic ,
  PlotLegends -> Automatic , ColorFunction → Hue, PlotPoints → 100]
```

Out[52]=



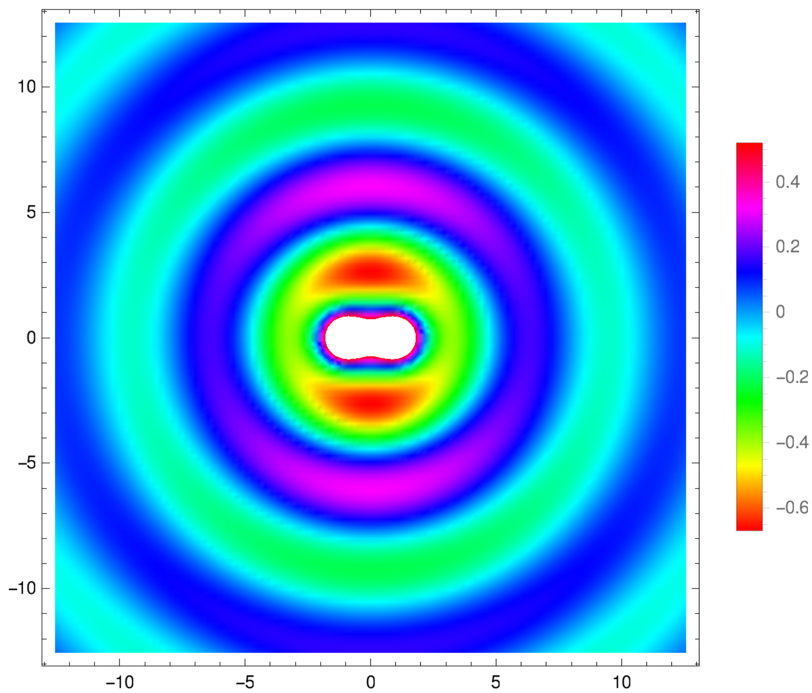
Two symmetric sources at x0=-1 and x0 = 1

```
psph1 = psph /. {x0 → 1, y0 → 0, z0 → 0, z → 0, k → 1};
psph2 = psph /. {x0 → -1, y0 → 0, z0 → 0, z → 0, k → 1};
psphTotal = psph1 + psph2
```

Out[55]=
$$\frac{e^{i\sqrt{\text{Abs}[-1+x]^2+\text{Abs}[y]^2}}}{\sqrt{\text{Abs}[-1+x]^2+\text{Abs}[y]^2}}+\frac{e^{i\sqrt{\text{Abs}[1+x]^2+\text{Abs}[y]^2}}}{\sqrt{\text{Abs}[1+x]^2+\text{Abs}[y]^2}}$$

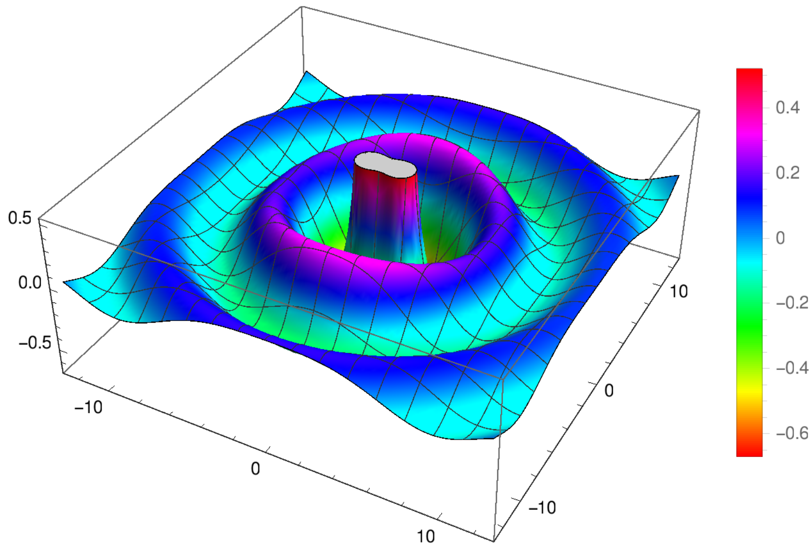
In[48]:=
```
DensityPlot[Re[psphTotal], {x, -4 π, 4 π}, {y, -4 π, 4 π}, PlotRange → Automatic ,
  PlotLegends -> Automatic , ColorFunction→ Hue, PlotPoints→ 100]
```

Out[48]=



In[49]:=
```
Plot3D[Re[psphTotal], {x, -4 π, 4 π}, {y, -4 π, 4 π}, PlotRange → Automatic ,
  PlotLegends -> Automatic , ColorFunction→ Hue, PlotPoints→ 100]
```

Out[49]=



In[68]:=
```
psph1 = psph /. {x0 → -3, y0 → 0, z0 → 0, z → 0, k → 1};
psph2 = psph /. {y0 → 0, z0 → 0, z → 0, k → 1};
psphTotal = psph1 + psph2
```

Out[70]=
$$\frac{e^{i \sqrt{\text{Abs}[3+x]^2+\text{Abs}[y]^2}}}{\sqrt{\text{Abs}[3+x]^2+\text{Abs}[y]^2}}+\frac{e^{i \sqrt{\text{Abs}[x-x0]^2+\text{Abs}[y]^2}}}{\sqrt{\text{Abs}[x-x0]^2+\text{Abs}[y]^2}}$$

In[60]:=
```
psphTotal
```

Out[60]=
$$\frac{e^{i \sqrt{\text{Abs}[-1+x]^2+\text{Abs}[y]^2}}}{\sqrt{\text{Abs}[-1+x]^2+\text{Abs}[y]^2}}+\frac{e^{i \sqrt{\text{Abs}[x-x0]^2+\text{Abs}[y]^2}}}{\sqrt{\text{Abs}[x-x0]^2+\text{Abs}[y]^2}}$$

In[72]:=
```
Animate [DensityPlot[Re[psphTotal] /. x0 → a, {x, -4 π, 4 π}, {y, -4 π, 4 π},
    PlotRange → Automatic , PlotLegends -> Automatic , ColorFunction→ Hue,
    PlotPoints→ 100], {a, 1, 10, 1}, AnimationRunning → False]
```

N-source problem

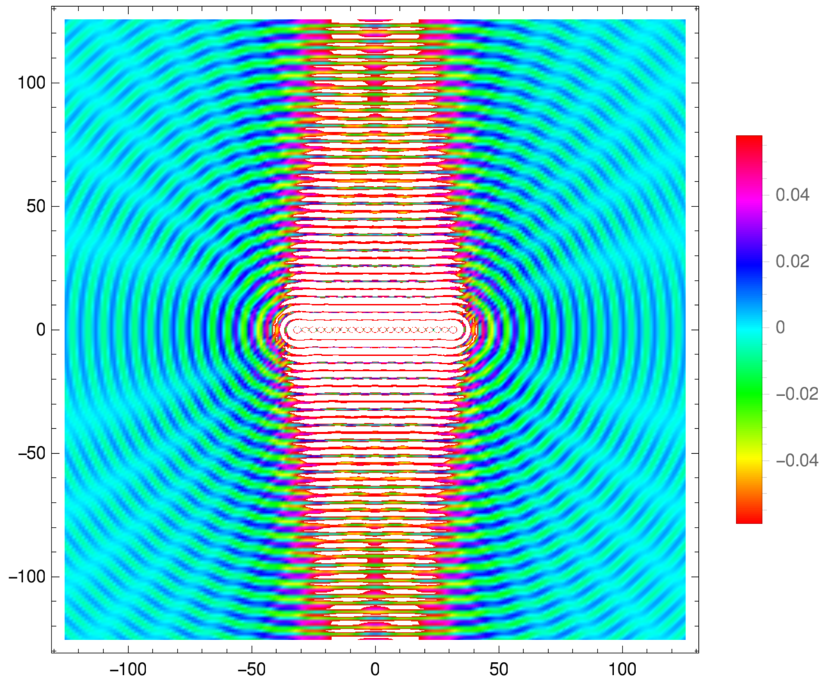
In[80]:=
```
Clear[psphTotal]
```

In[93]:=
```
Nsources = 20;
xp = Table[x, {x, -10 π, 10 π, 20 π/Nsources}]
psphTotal = Sum [psph /. {x0 → xp[[n]], y0 → 0, z0 → 0, z → 0, k → 1}, {n, 1, Nsources + 1}];
```

Out[94]=
```
{-10 π, -9 π, -8 π, -7 π, -6 π, -5 π, -4 π, -3 π,
  -2 π, -π, 0, π, 2 π, 3 π, 4 π, 5 π, 6 π, 7 π, 8 π, 9 π, 10 π}
```

In[102]:=
```
DensityPlot[Re[psphTotal], {x, -2 Nsources π, 2 Nsources π},
  {y, -2 Nsources π, 2 Nsources π}, PlotRange → Automatic ,
  PlotLegends → Automatic , ColorFunction→ Hue, PlotPoints→ 200]
```

Out[102]=



In[114]:=
```
DensityPlot[Abs[psphTotal], {x, -Nsources π, Nsources π},
  {y, 10 π, 20 Nsources π}, PlotRange → Automatic ,
  PlotLegends → Automatic , ColorFunction→ "Rainbow", PlotPoints→ 300]
```

Out[114]=