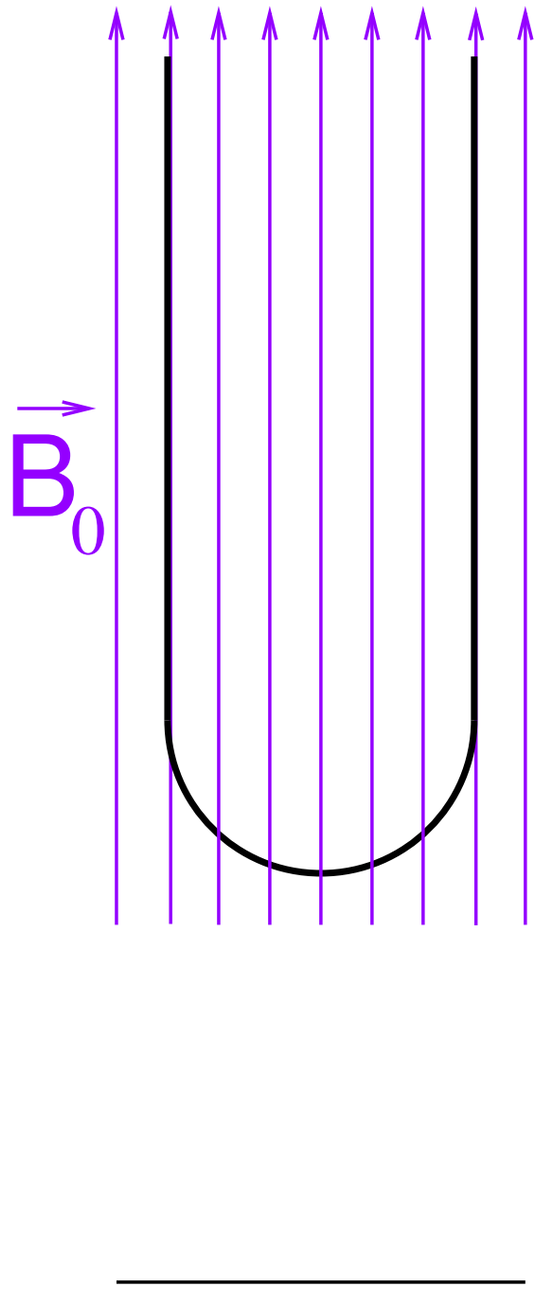
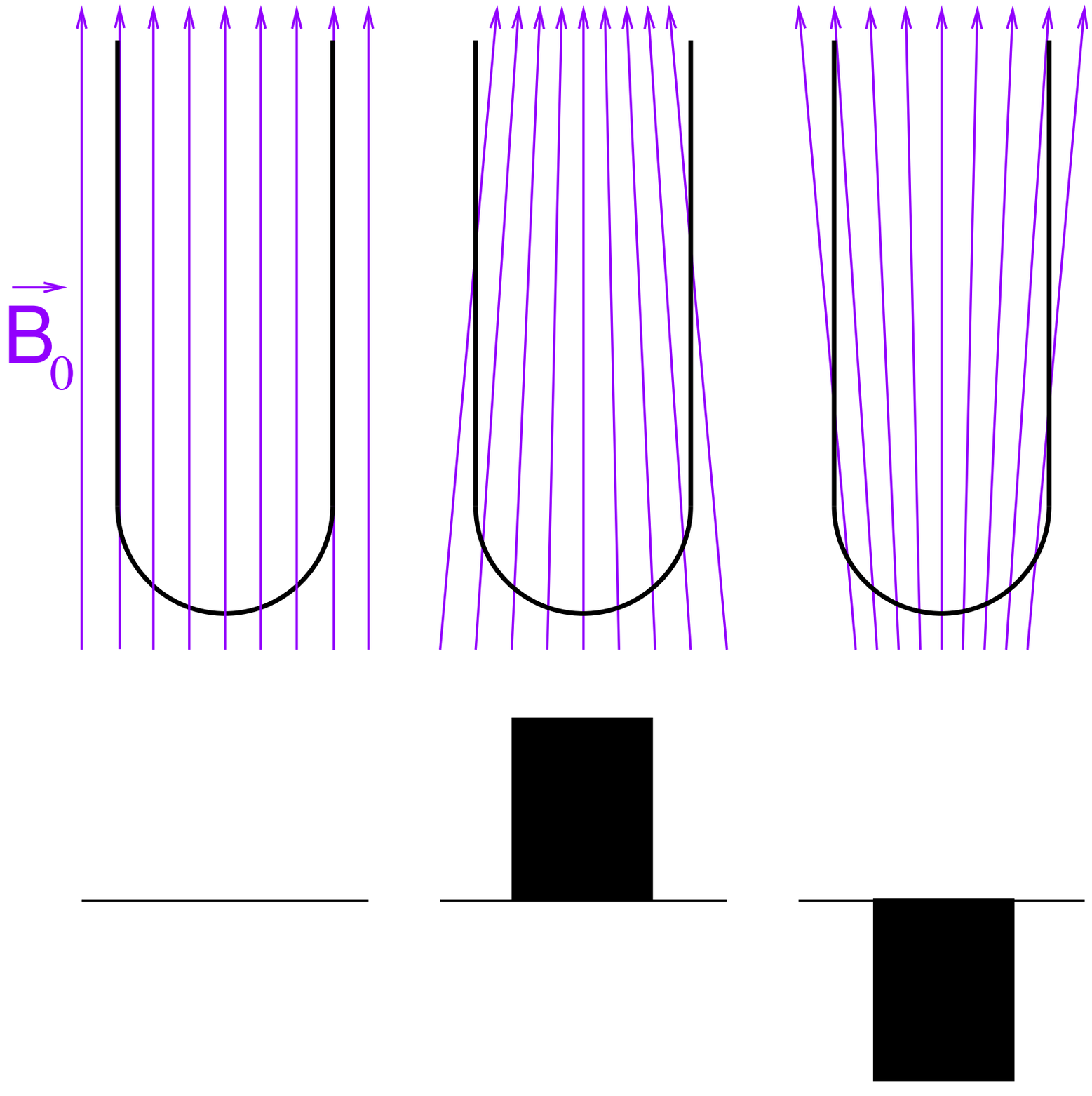
Lecture 13: Field gradients

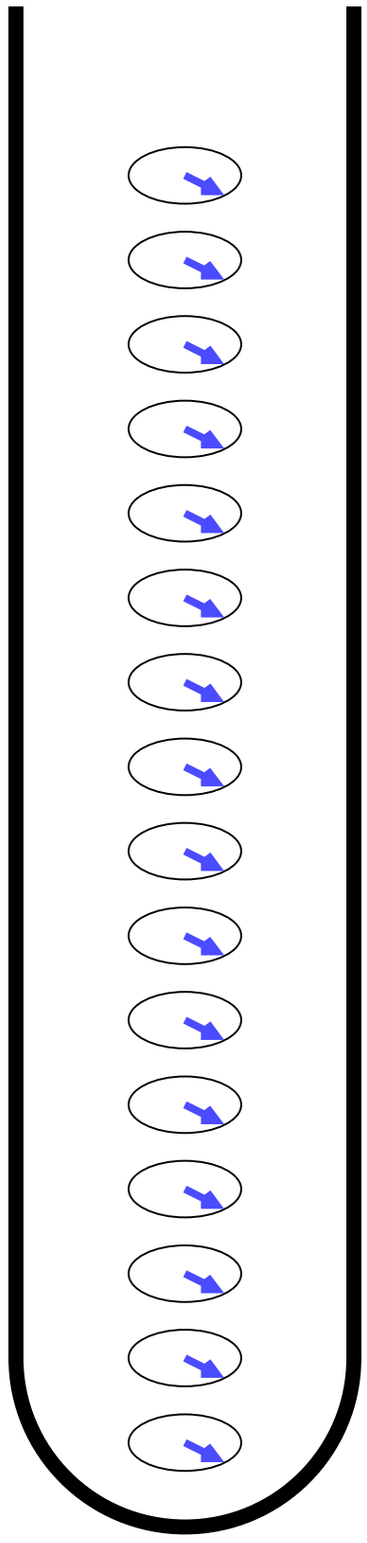
Homogeneous field



Pulsed field gradients (G_z)

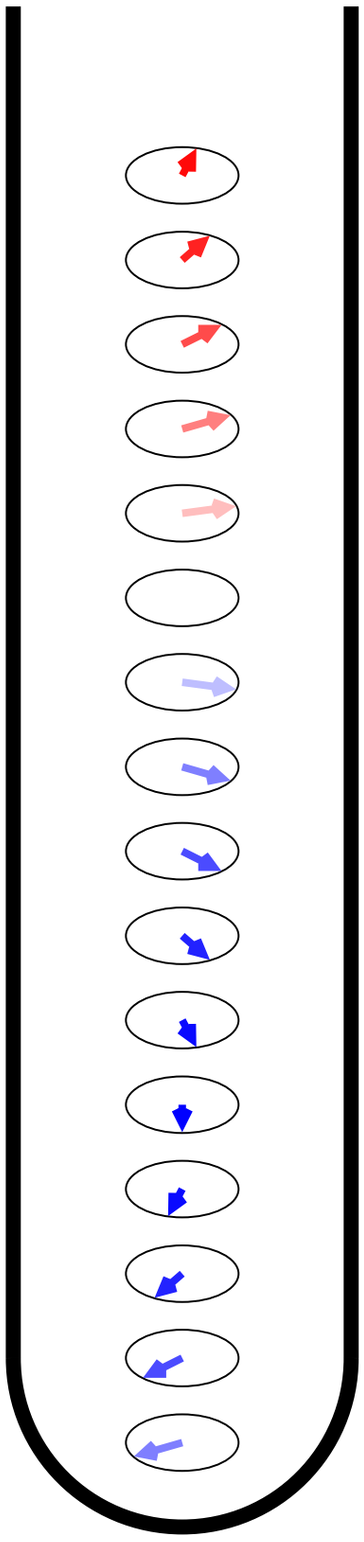


Gradients dephase transverse magnetization



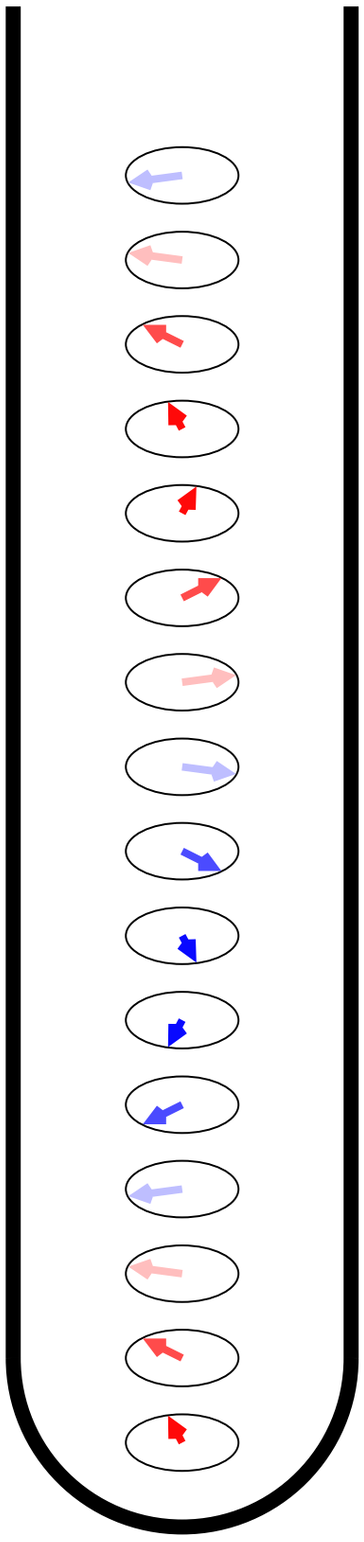
$G_z = 0$ units

Gradients dephase transverse magnetization



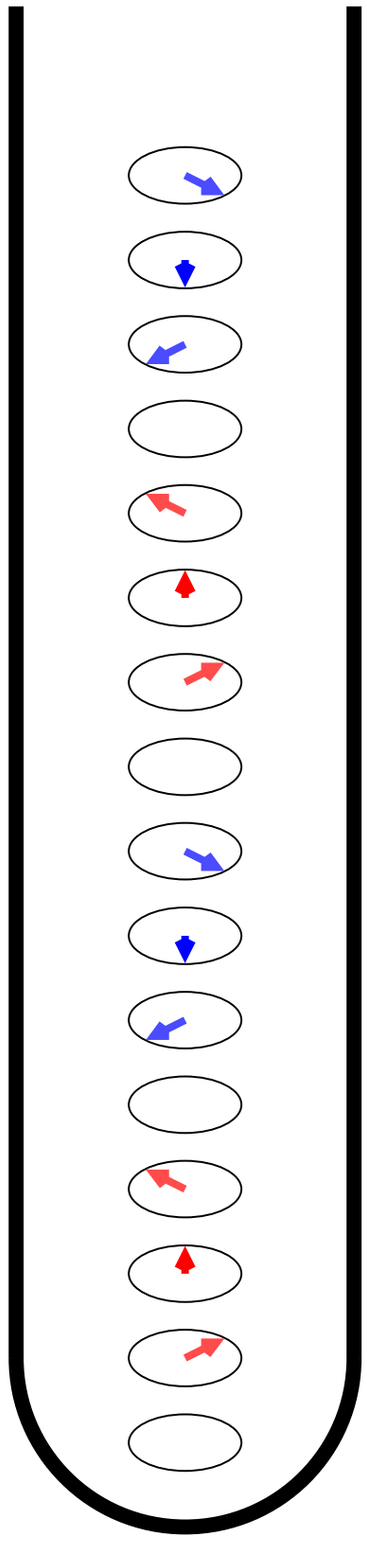
$G_z = 1$ units

Gradients dephase transverse magnetization



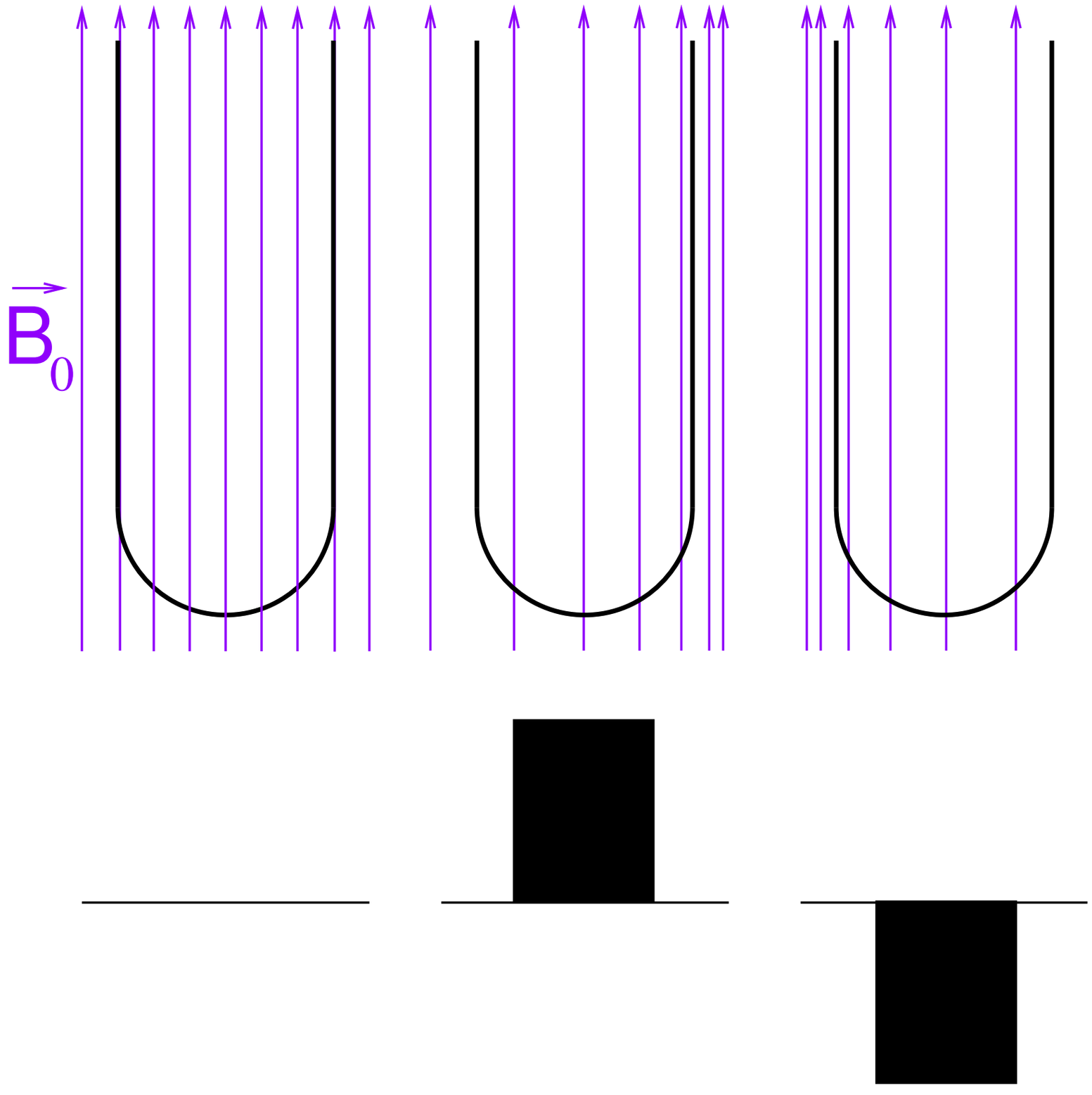
$G_z = 2$ units

Gradients dephase transverse magnetization

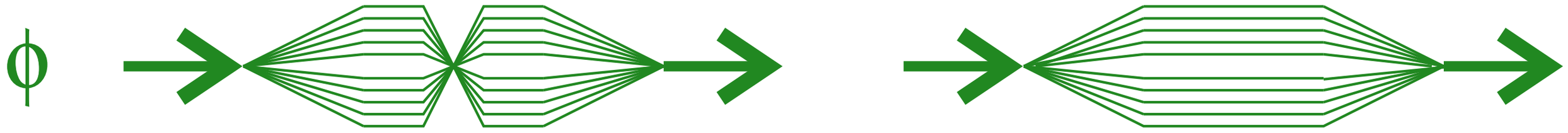


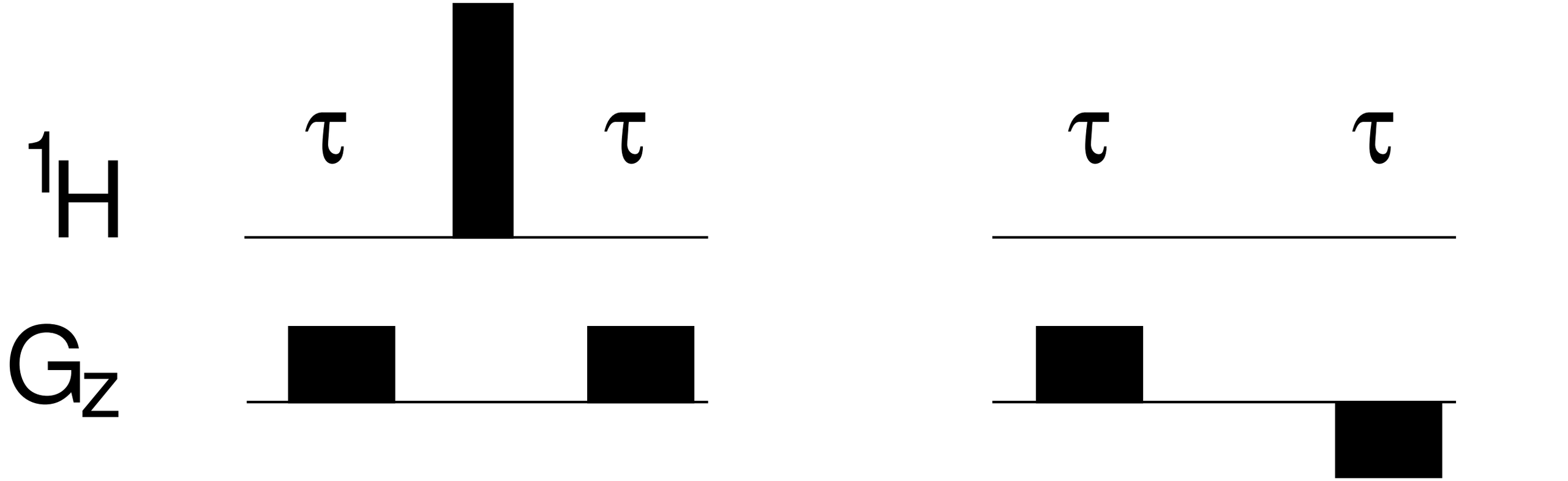
$G_z = 4$ units

Pulsed field gradients (G_y)



Gradient echoes





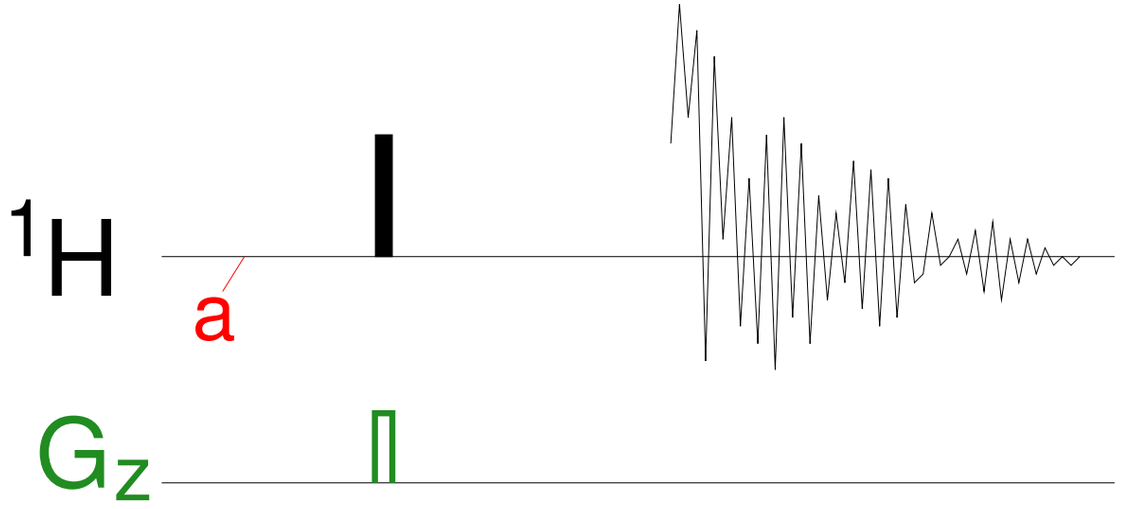
GRADIENTS
AND MAGNETIC RESONANCE IMAGING

Lars G. Hanson

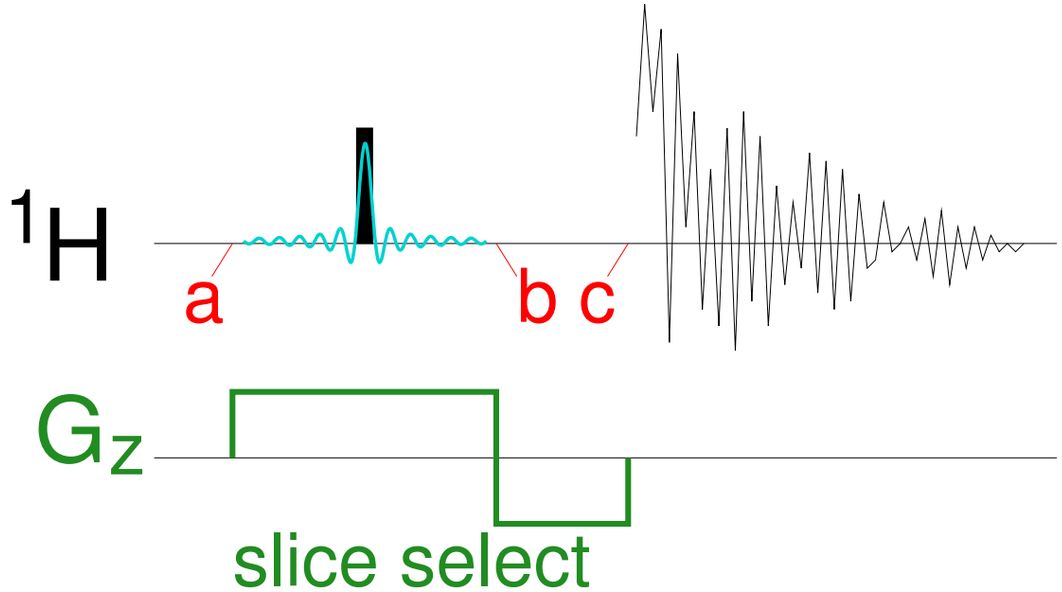
Copenhagen University Hospital Hvidovre

https://eprints.drcmr.dk/37/1/MRI_English_a4.pdf

Slice selection by G_z

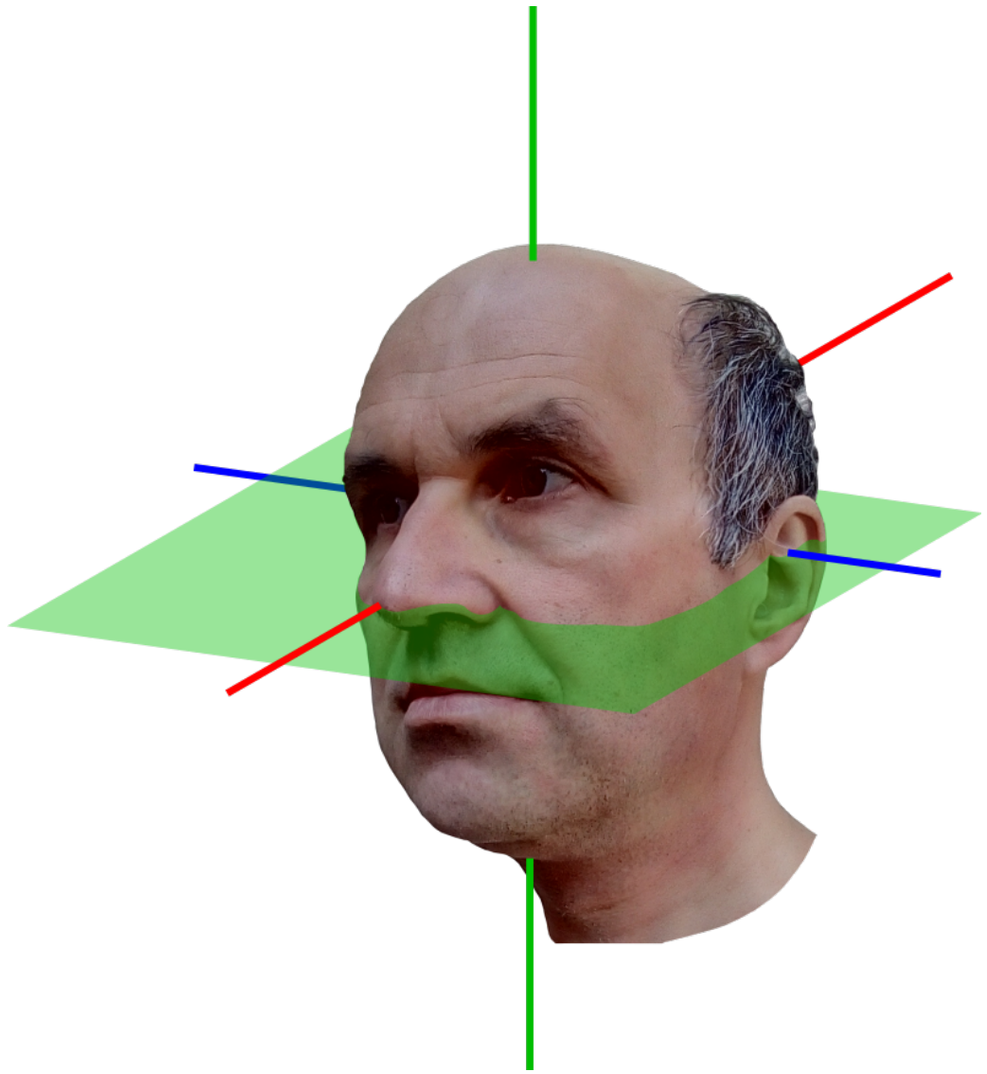


Slice selection by G_z

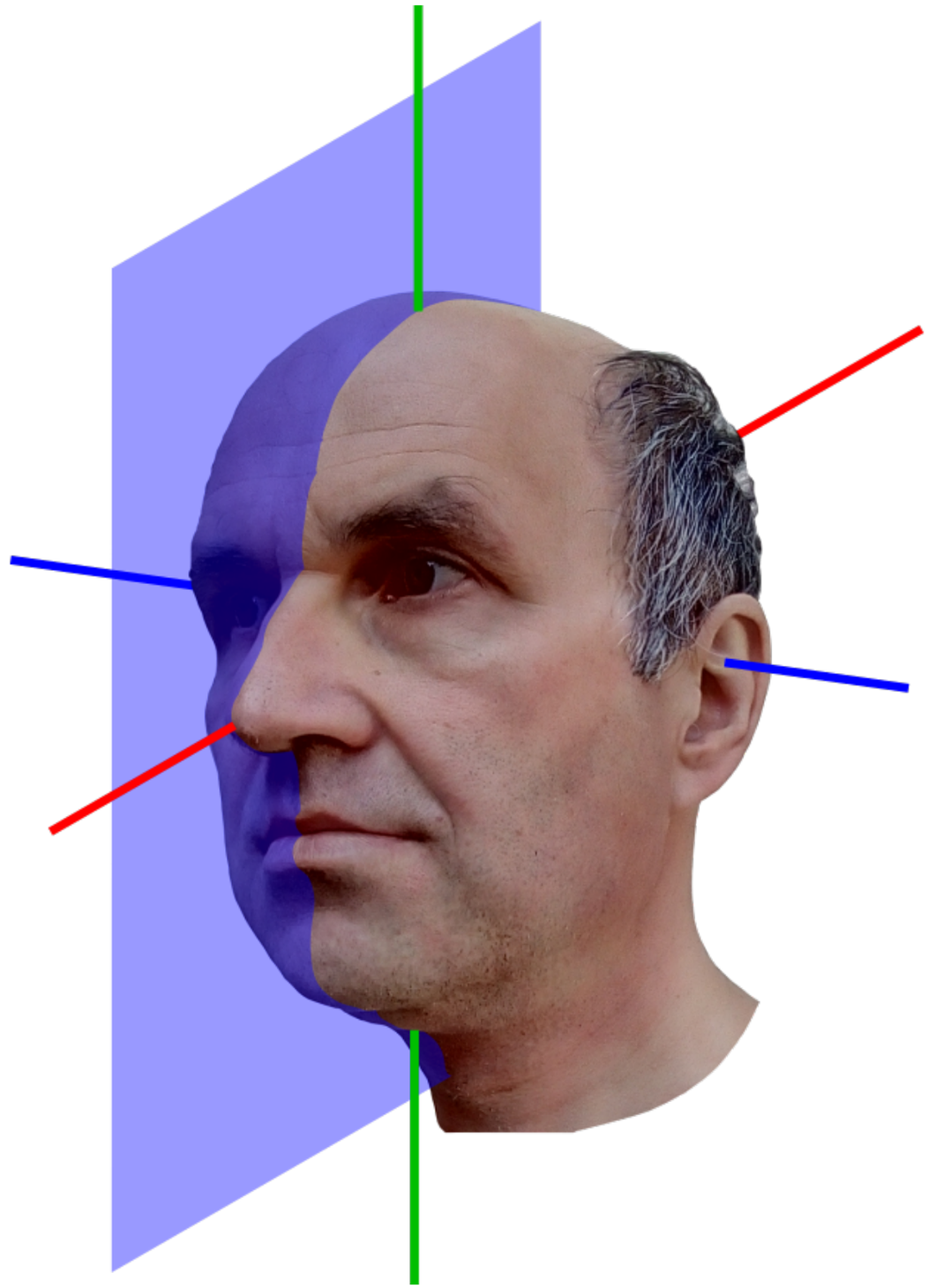


Selective pulse: **amplitude modulation**

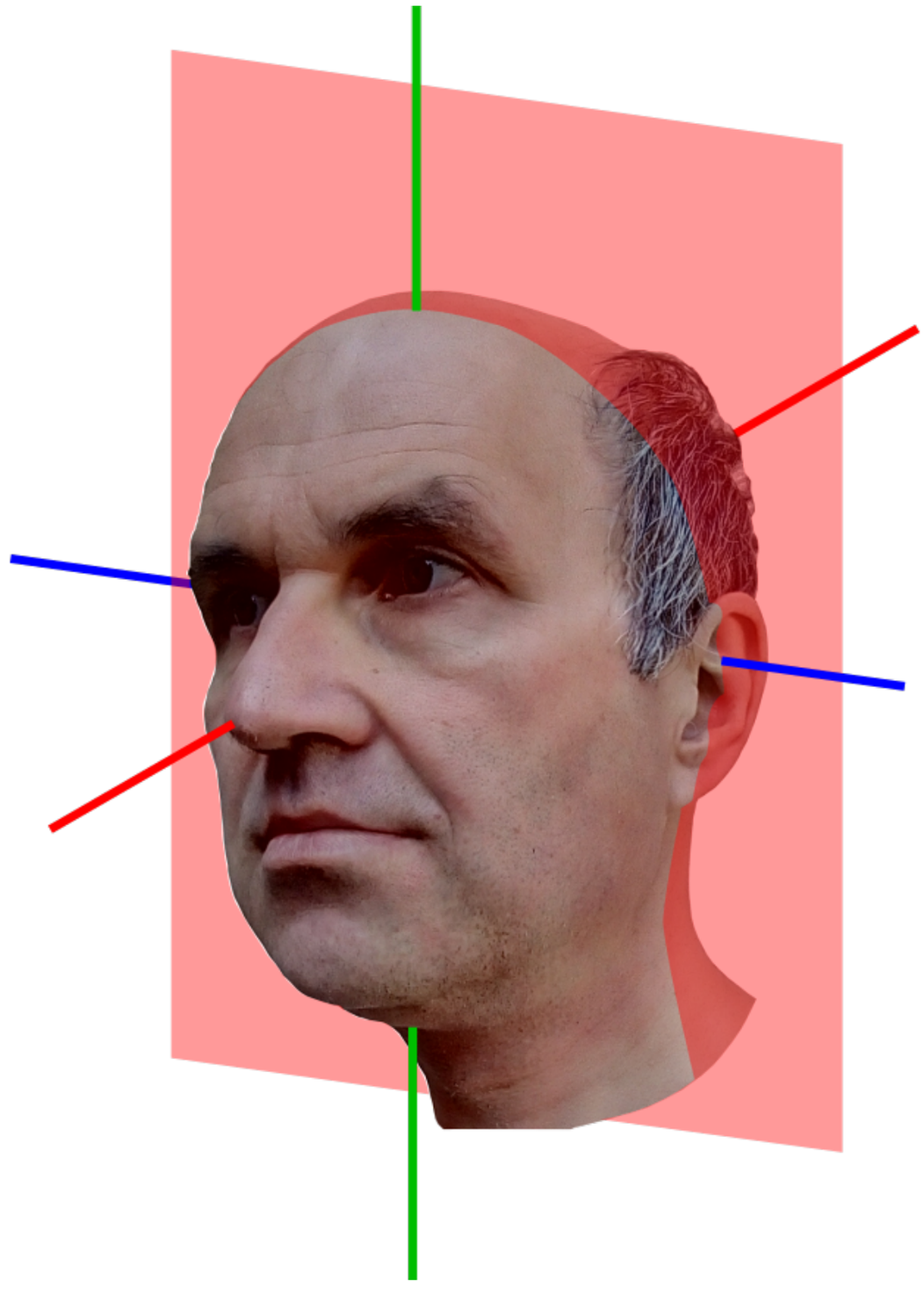
Axial slice selection by G_z



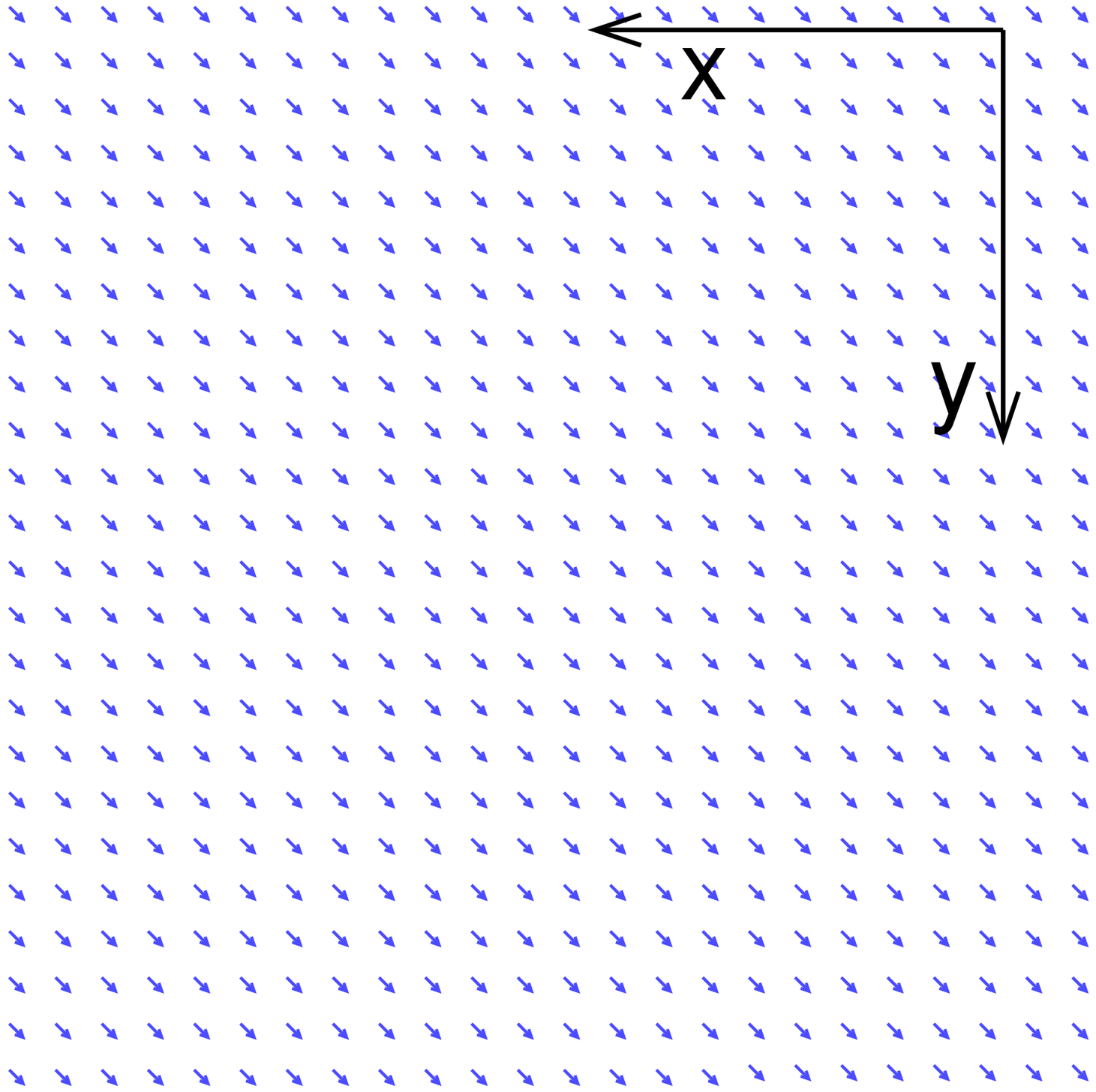
Sagittal slice selection by G_x



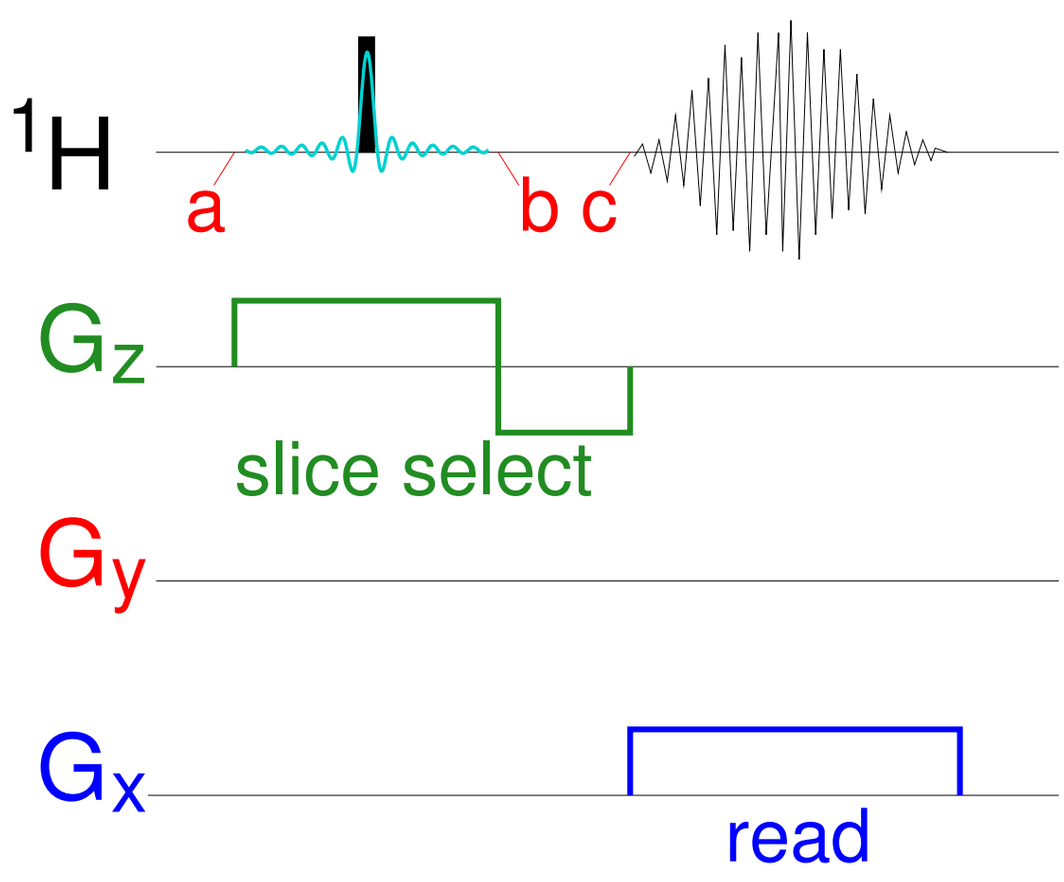
Coronal slice selection by G_y



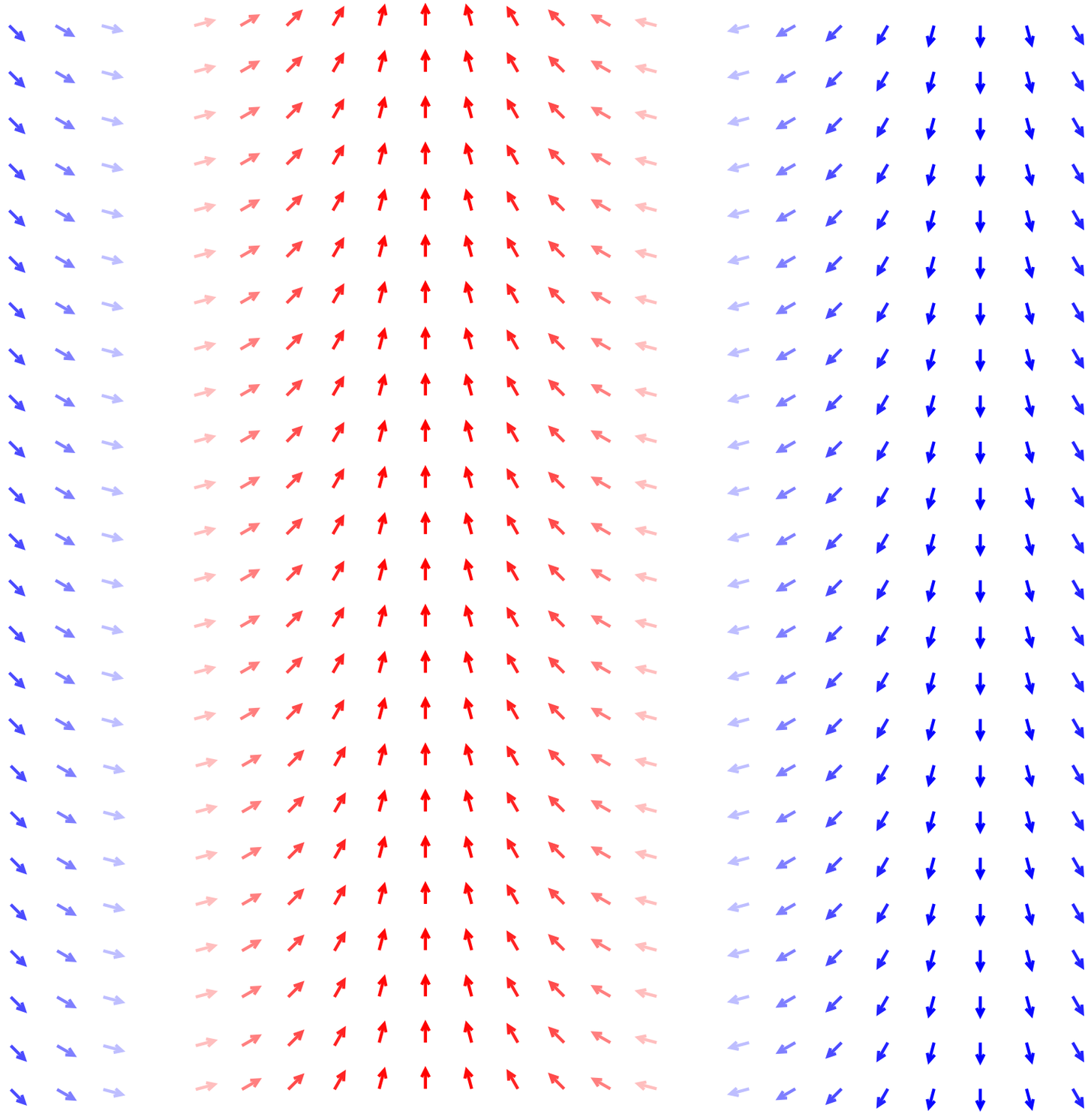
Magnetization in the slice



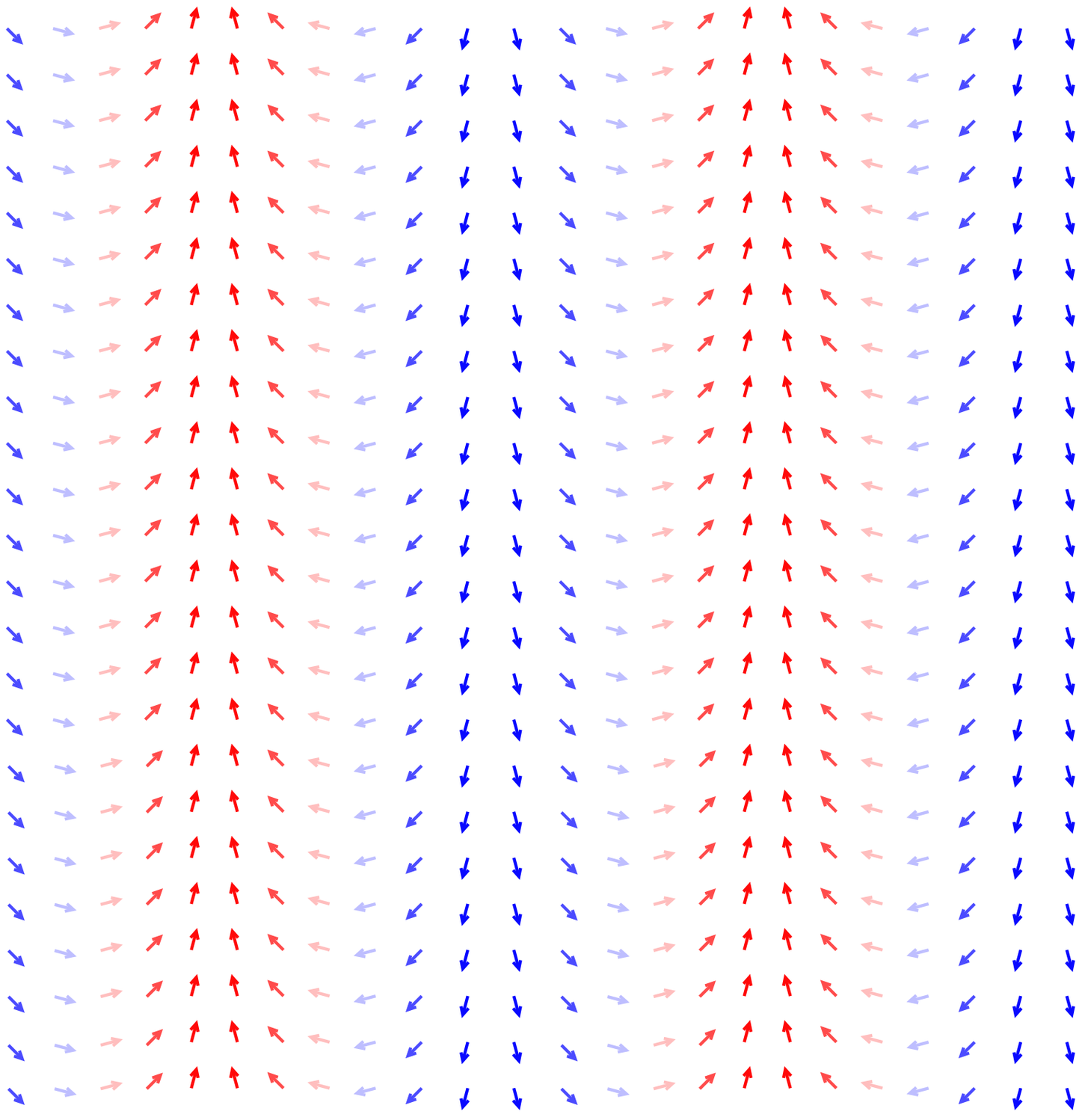
1D imaging in the slice



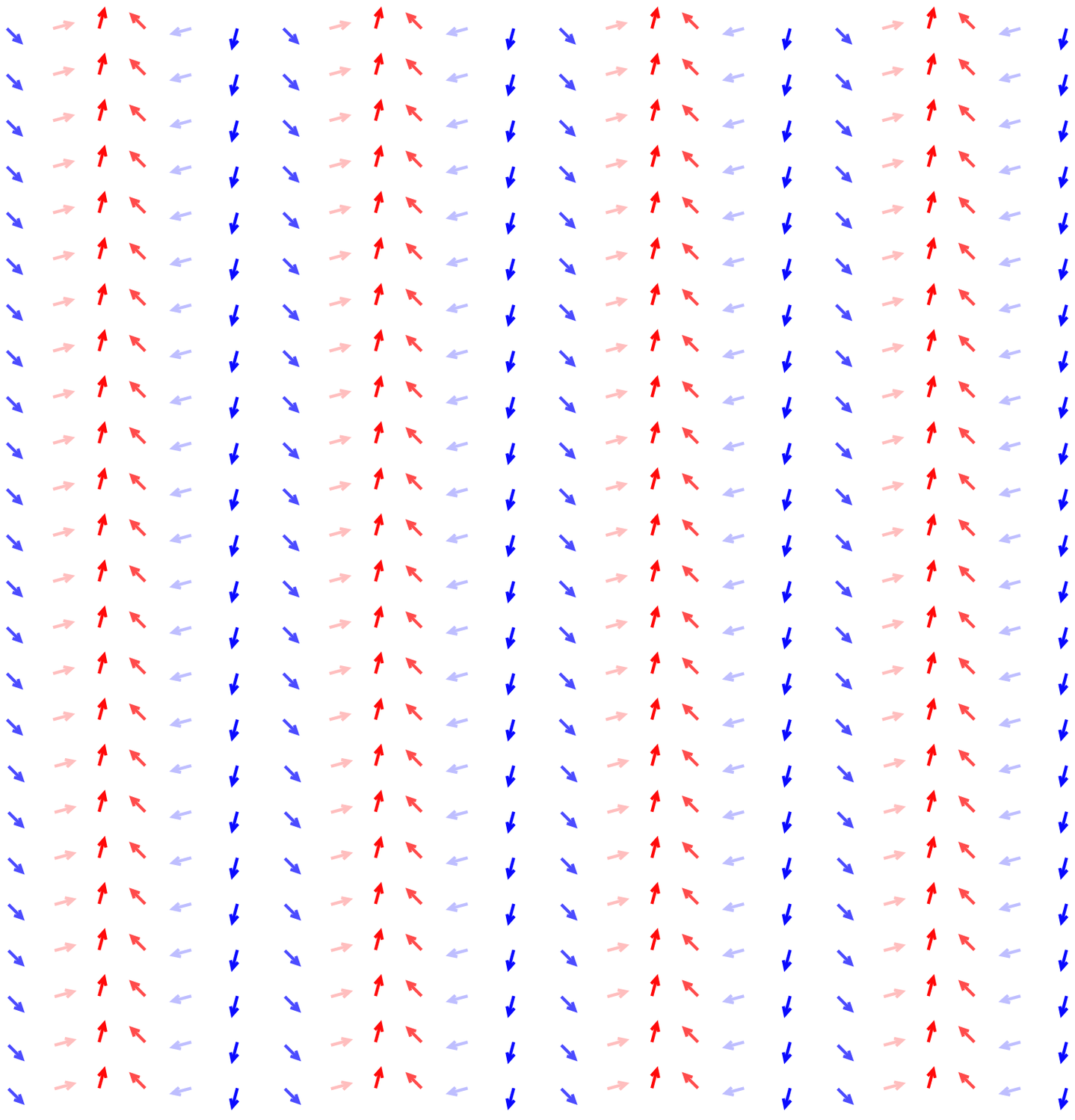
Magnetization in the slice with gradient G_x



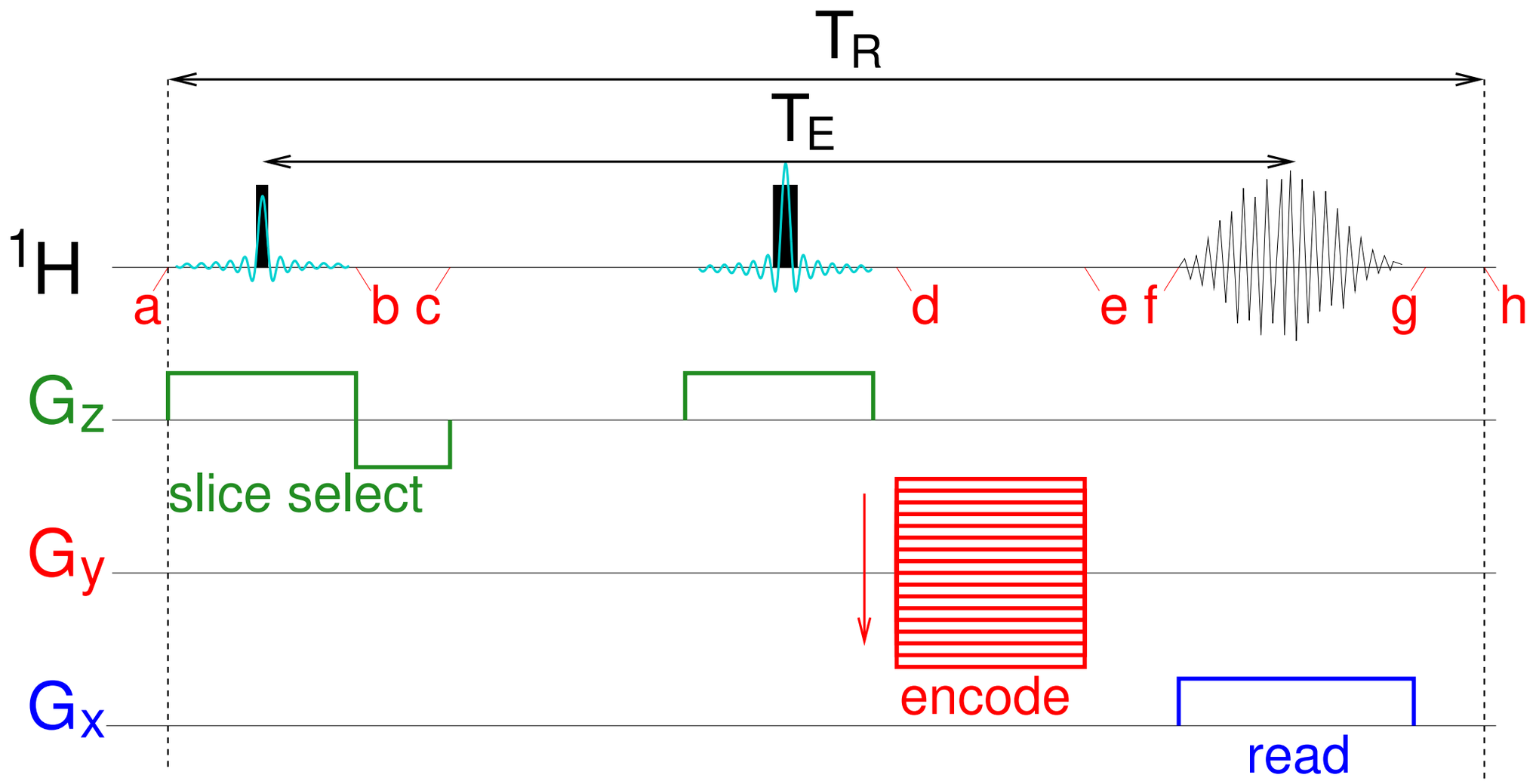
Magnetization in the slice with gradient G_x



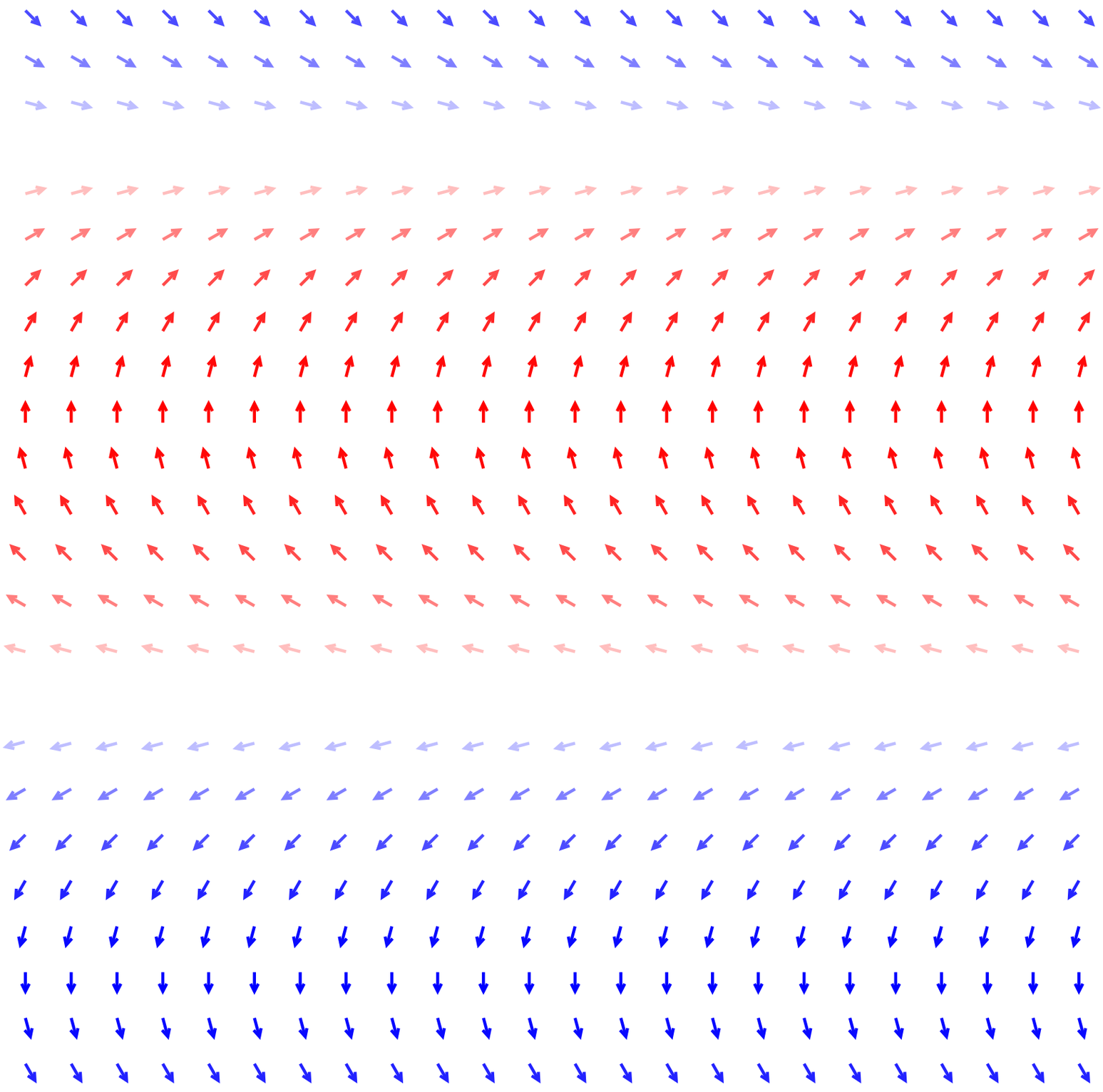
Magnetization in the slice with gradient G_x



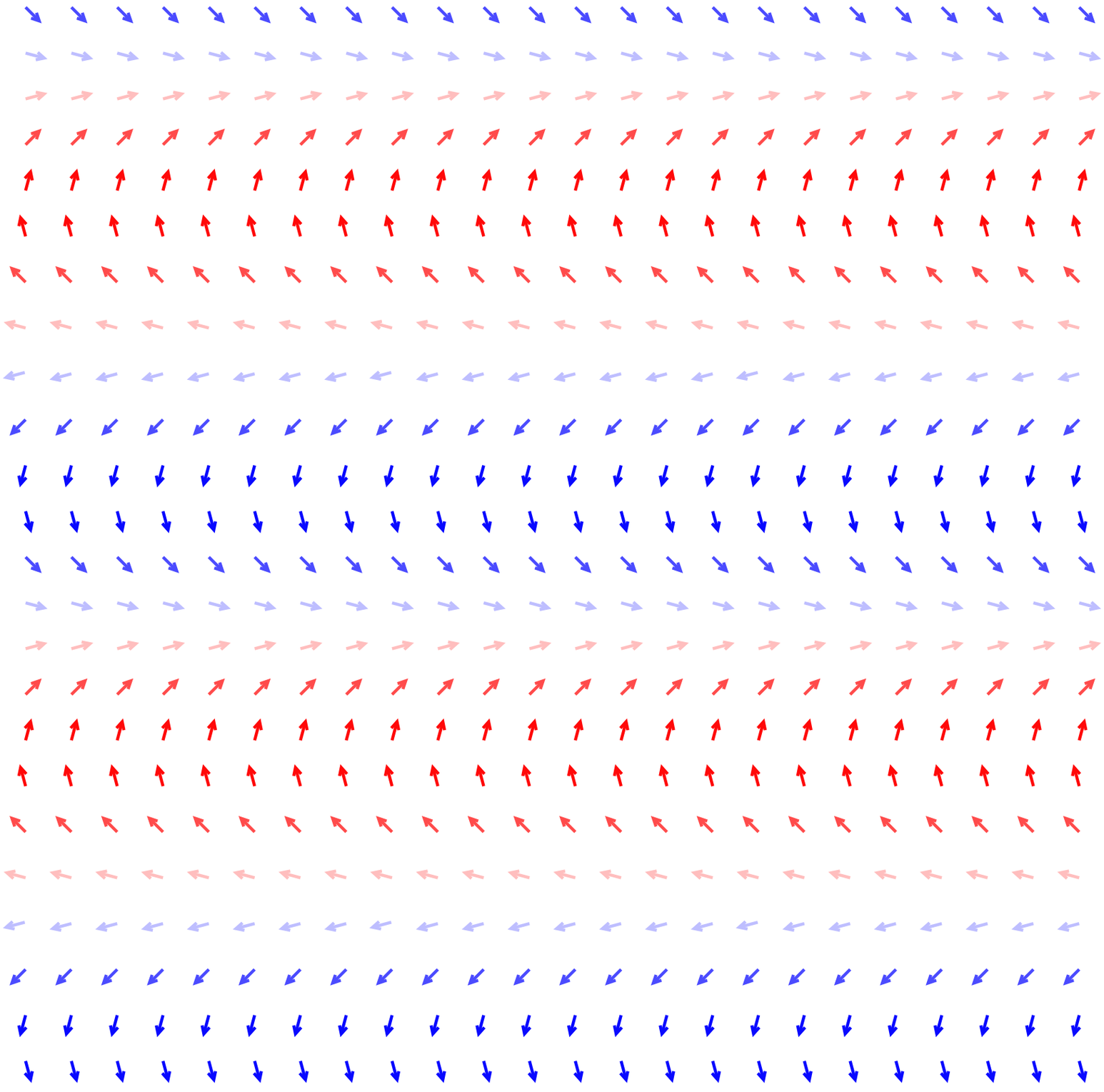
2D imaging in the slice



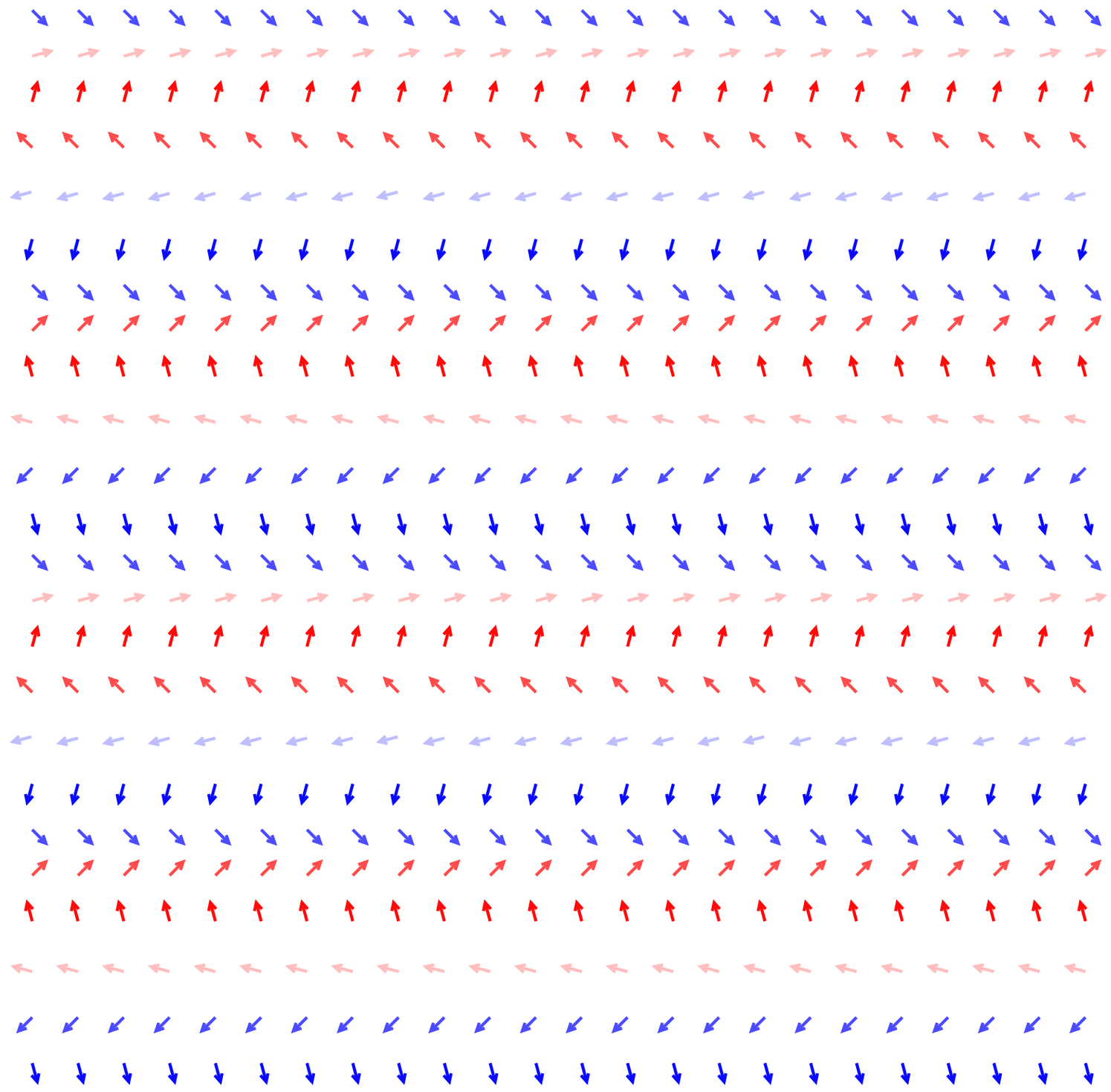
Magnetization in the slice with gradient G_y



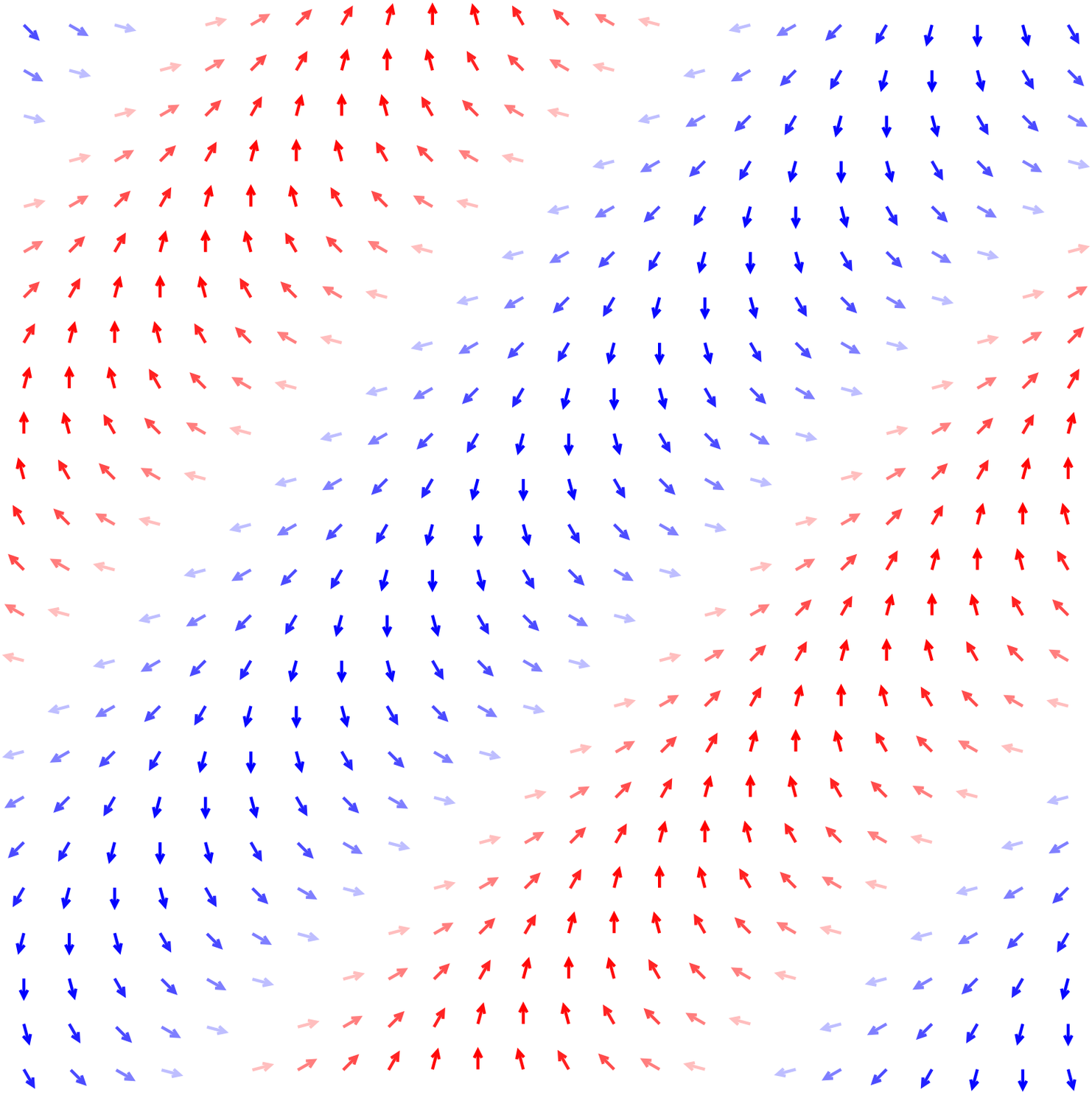
Magnetization in the slice with gradient G_y



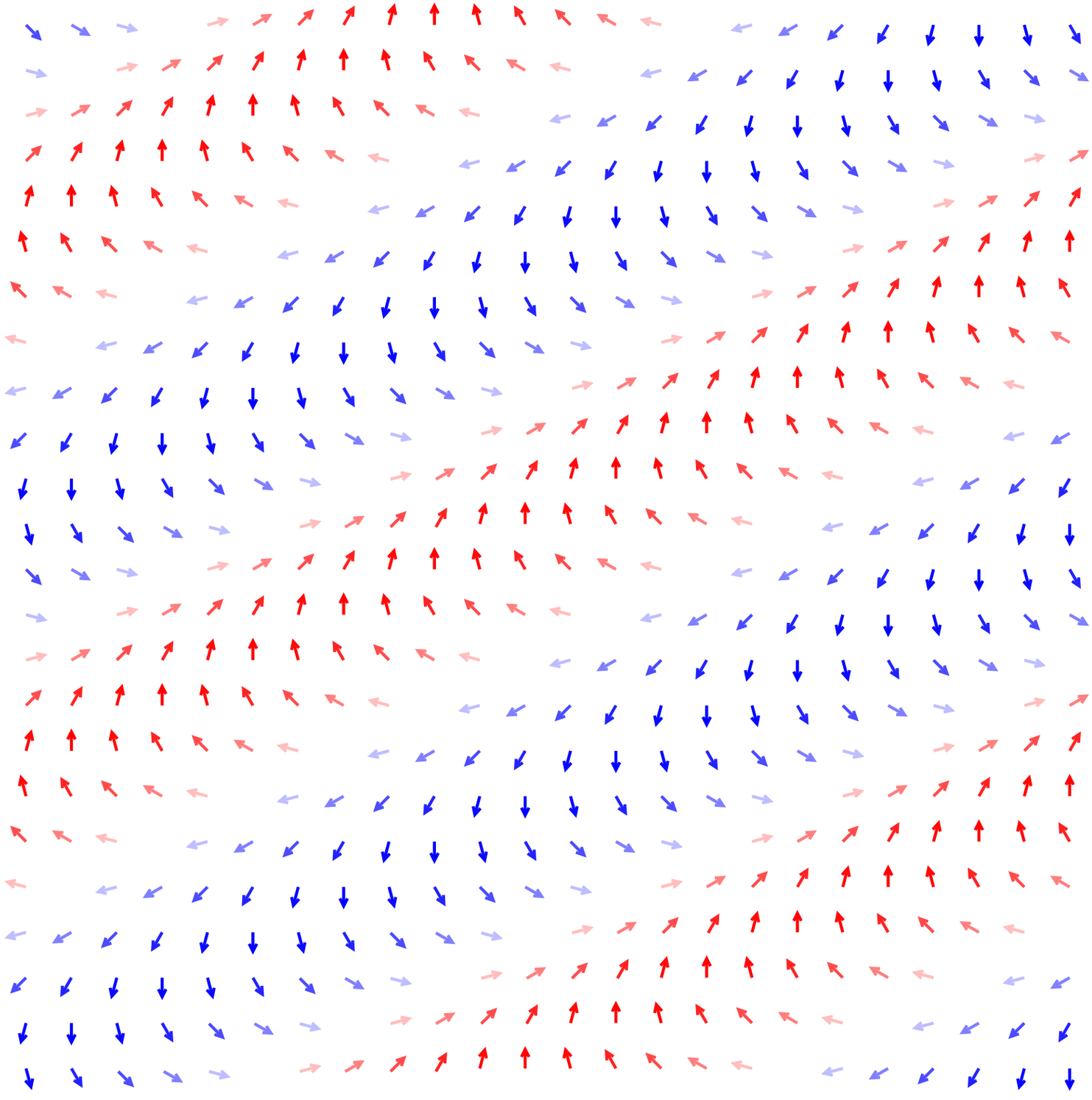
Magnetization in the slice with gradient G_y



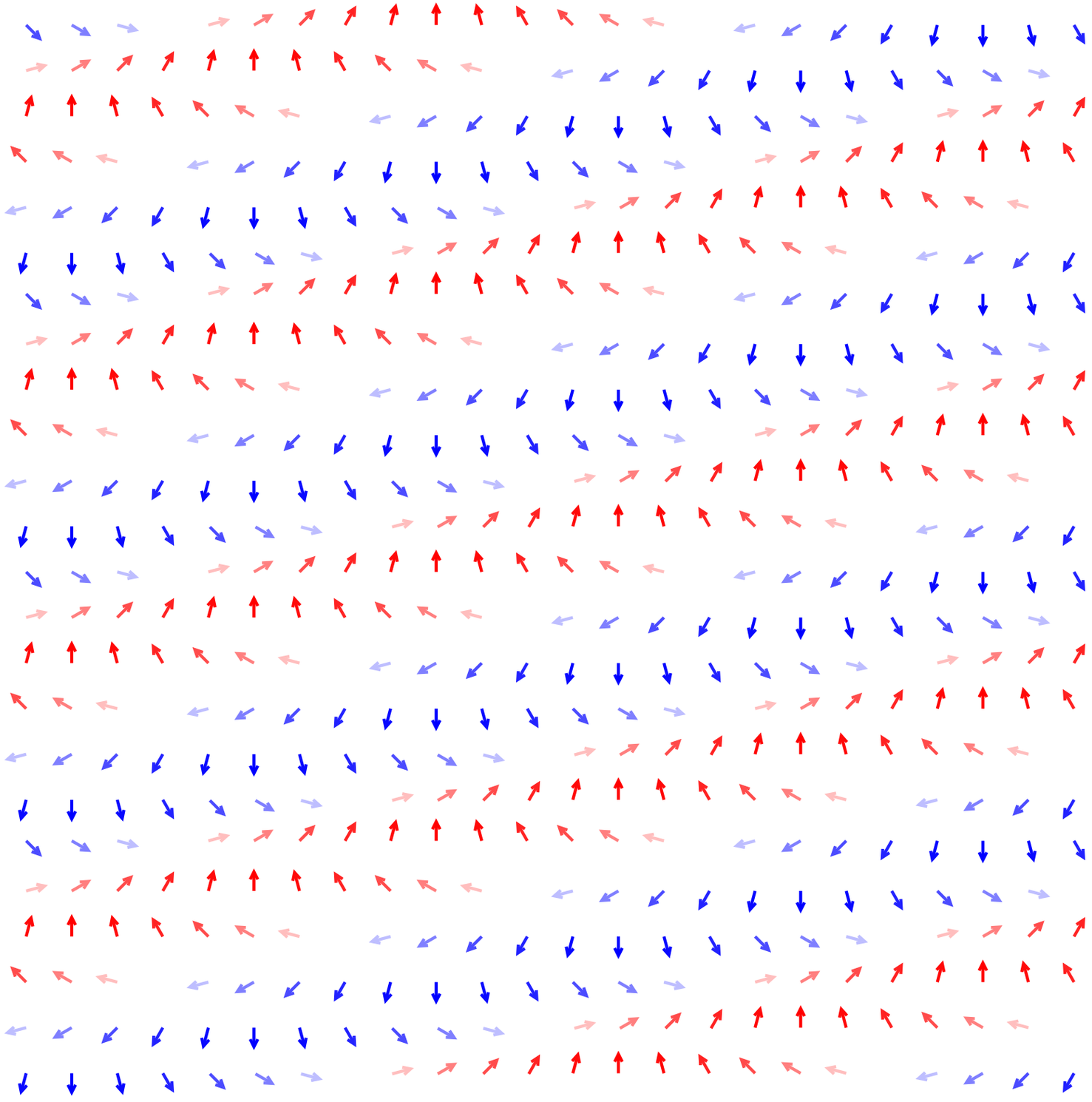
Combination of gradients G_x and G_y



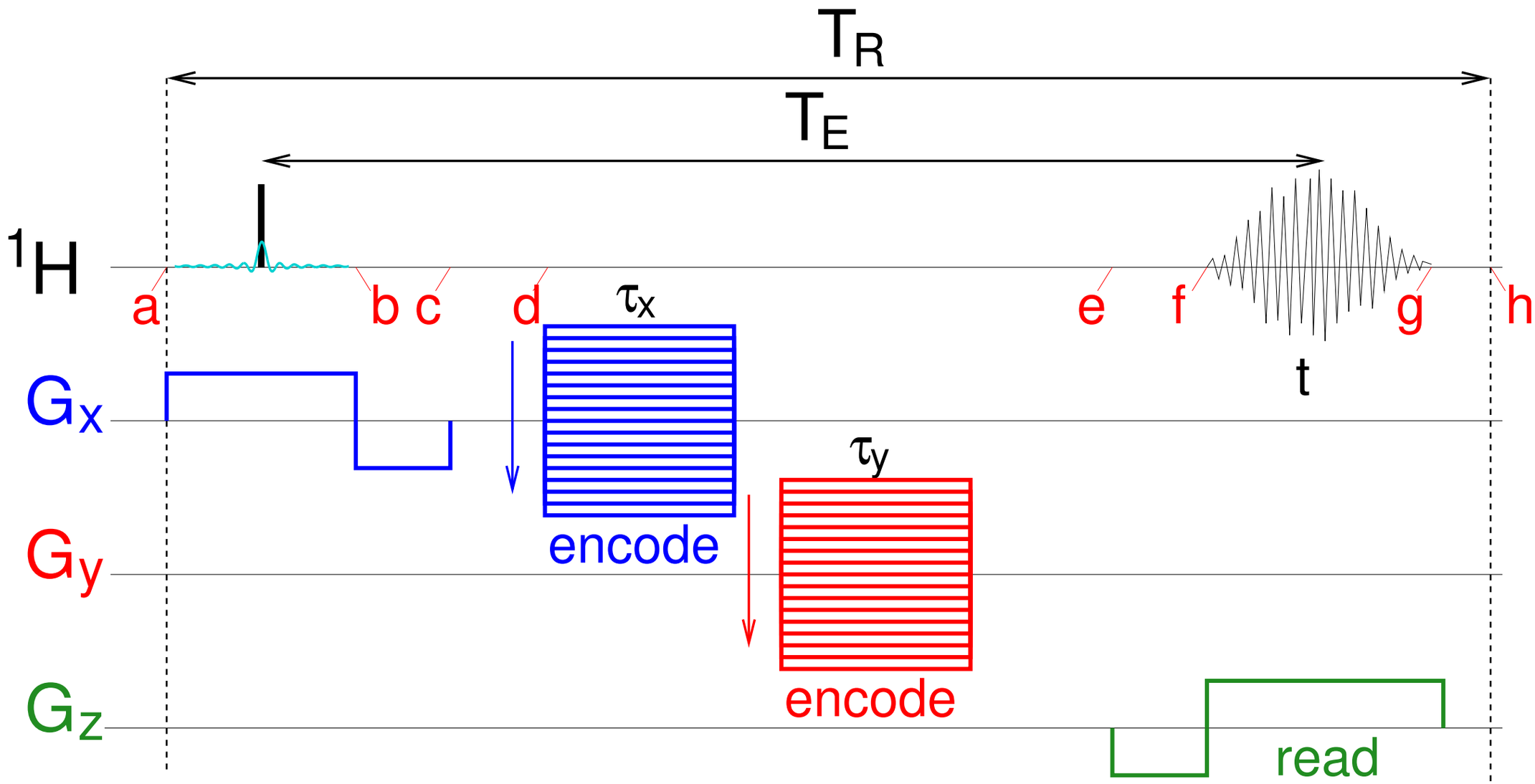
Combination of gradients G_x and G_y



Combination of gradients G_x and G_y



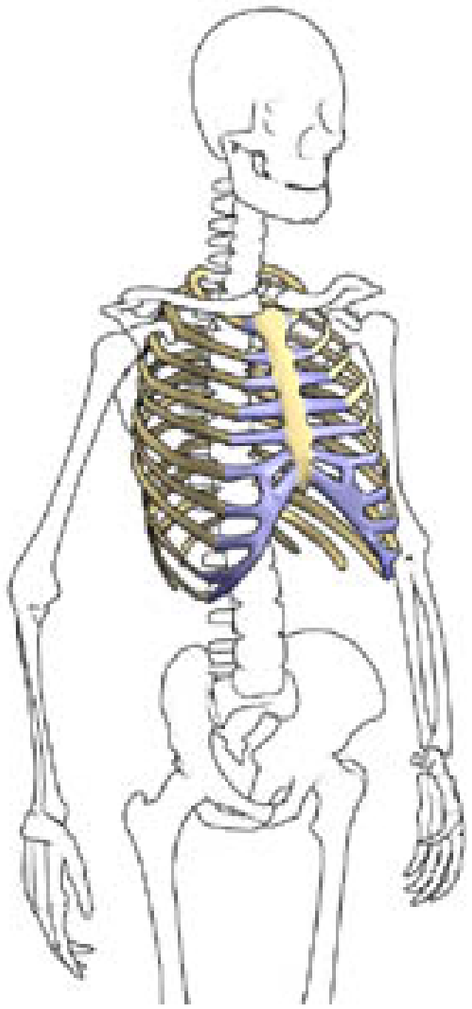
3D gradient echo imaging

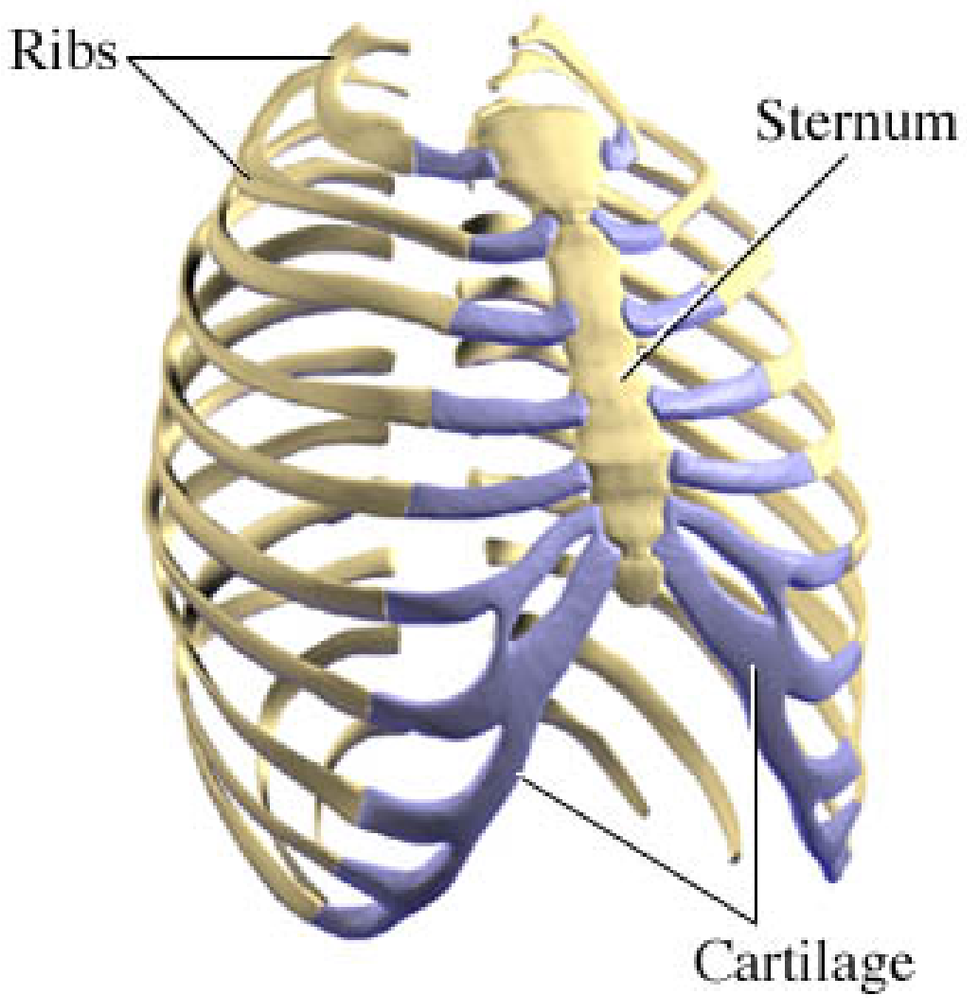


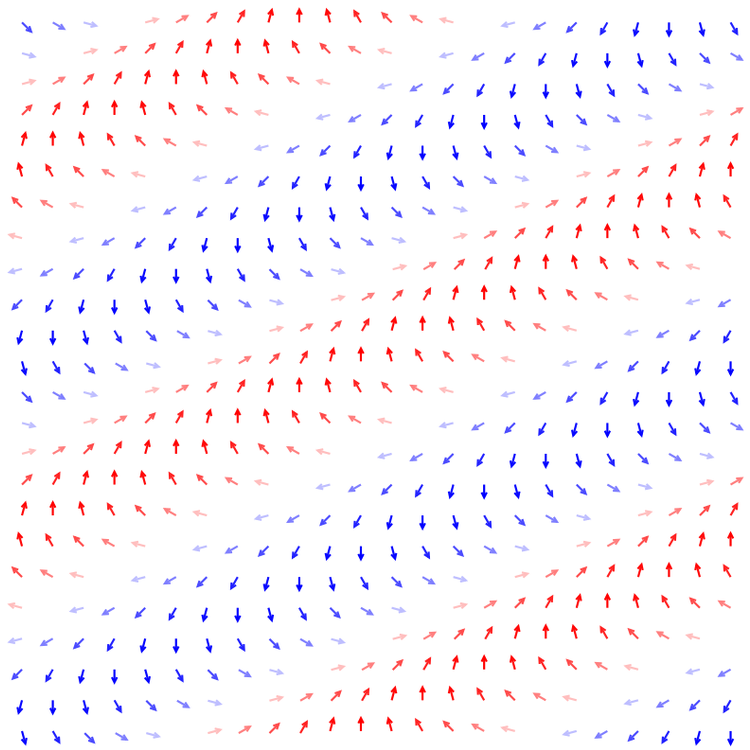
High resolution in all dimensions

More time consuming

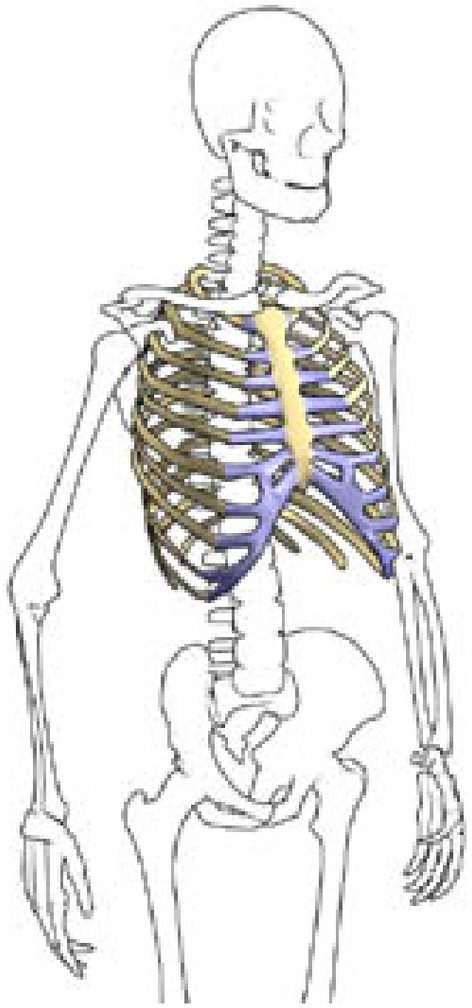
Regular patterns create signal

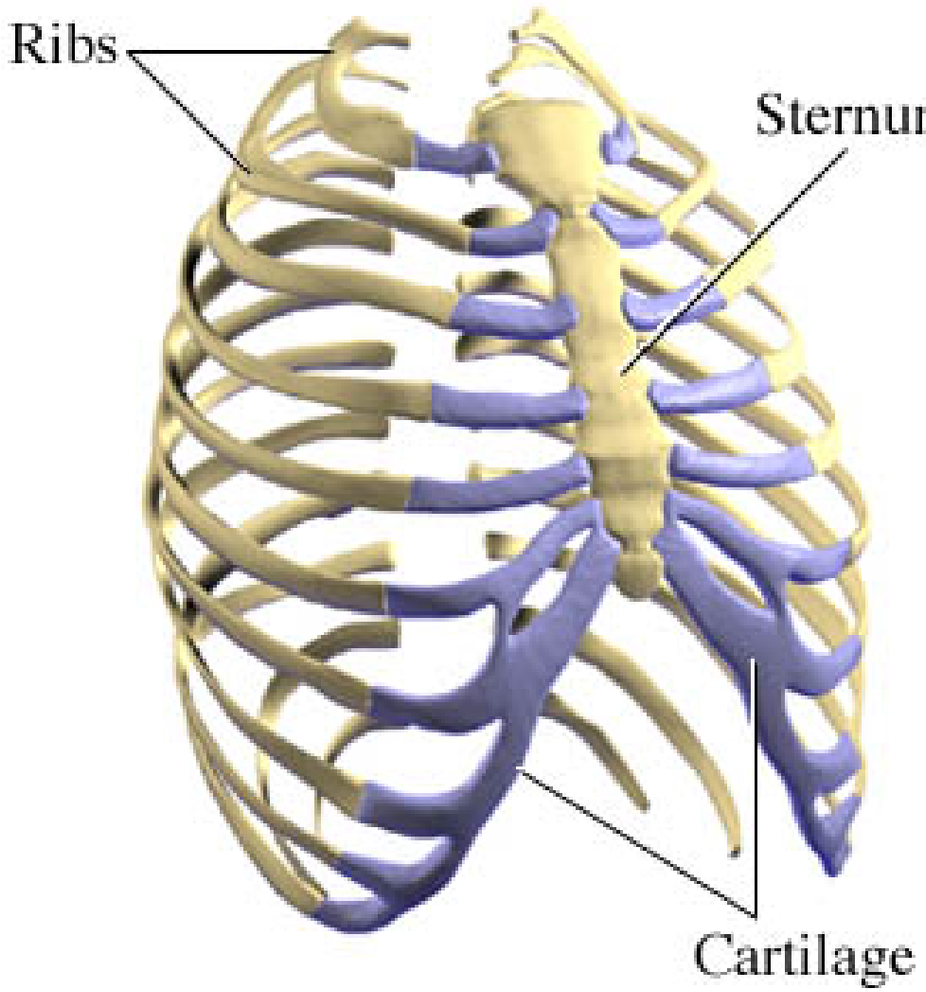


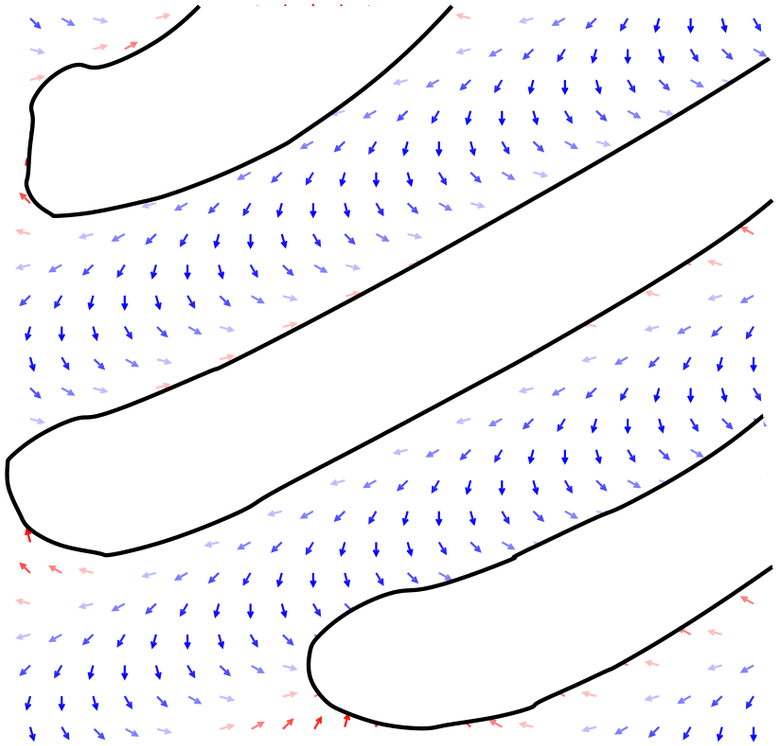




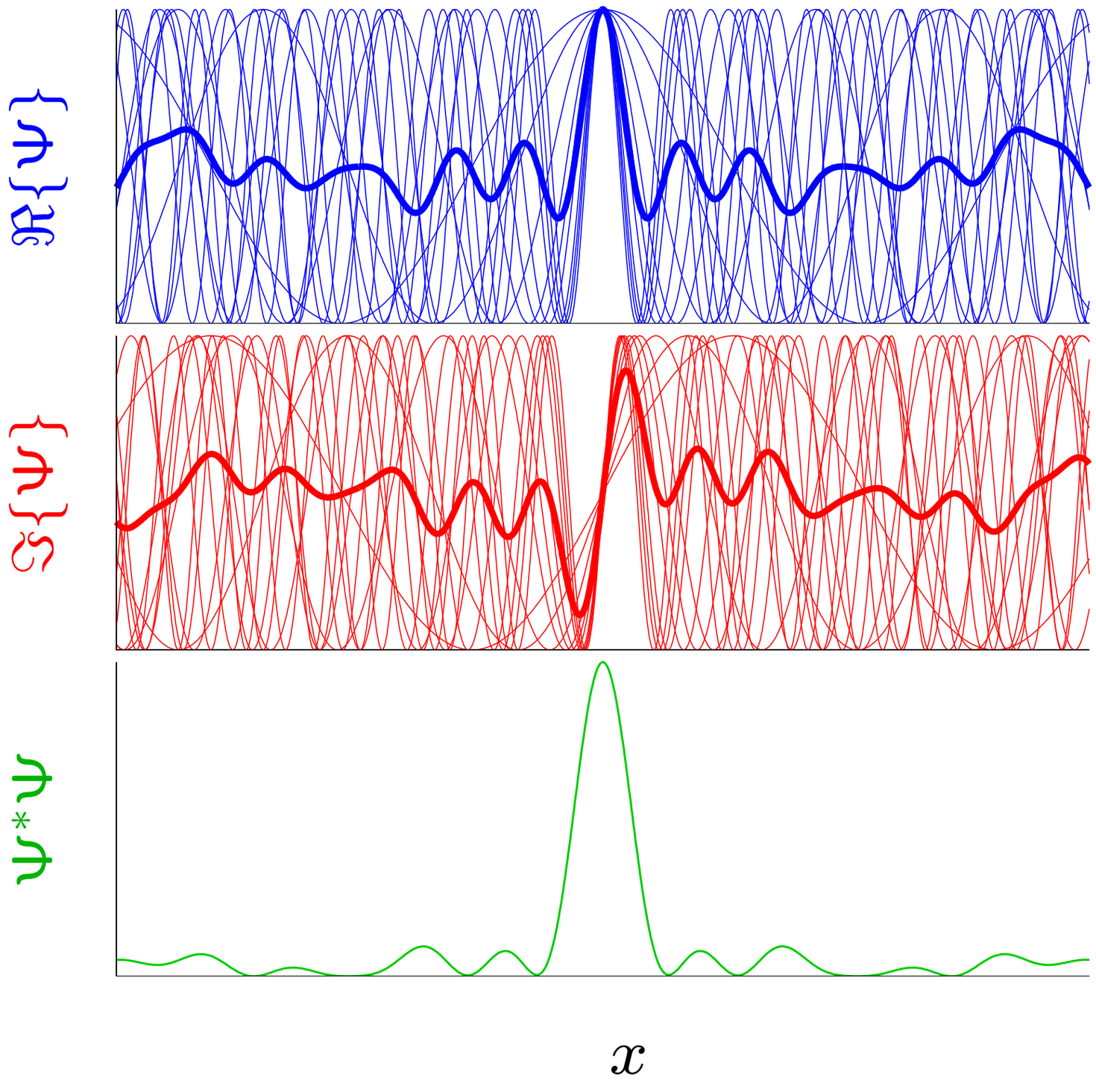
Regular patterns create signal





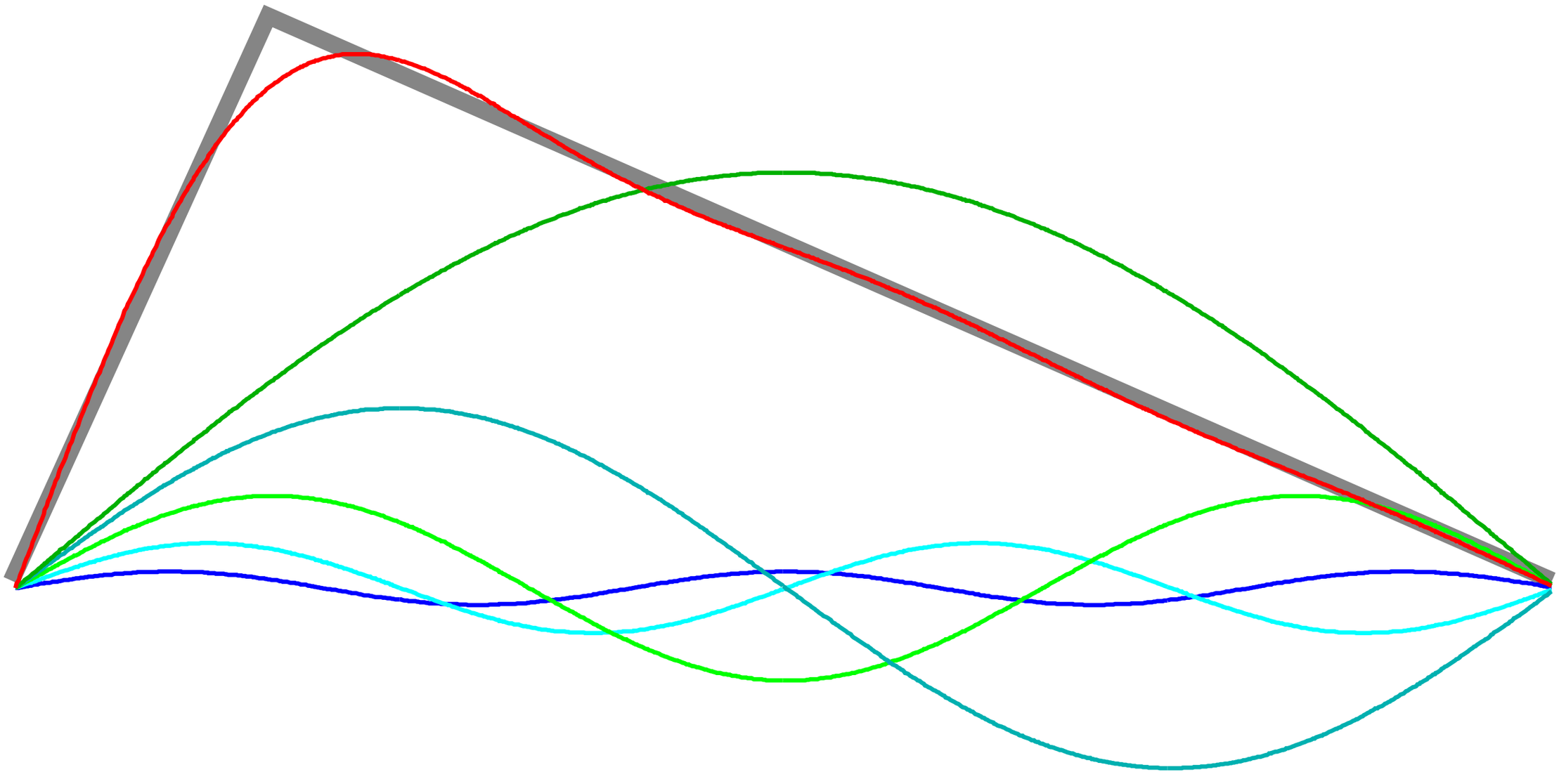


Unique shape as superposition of patterns

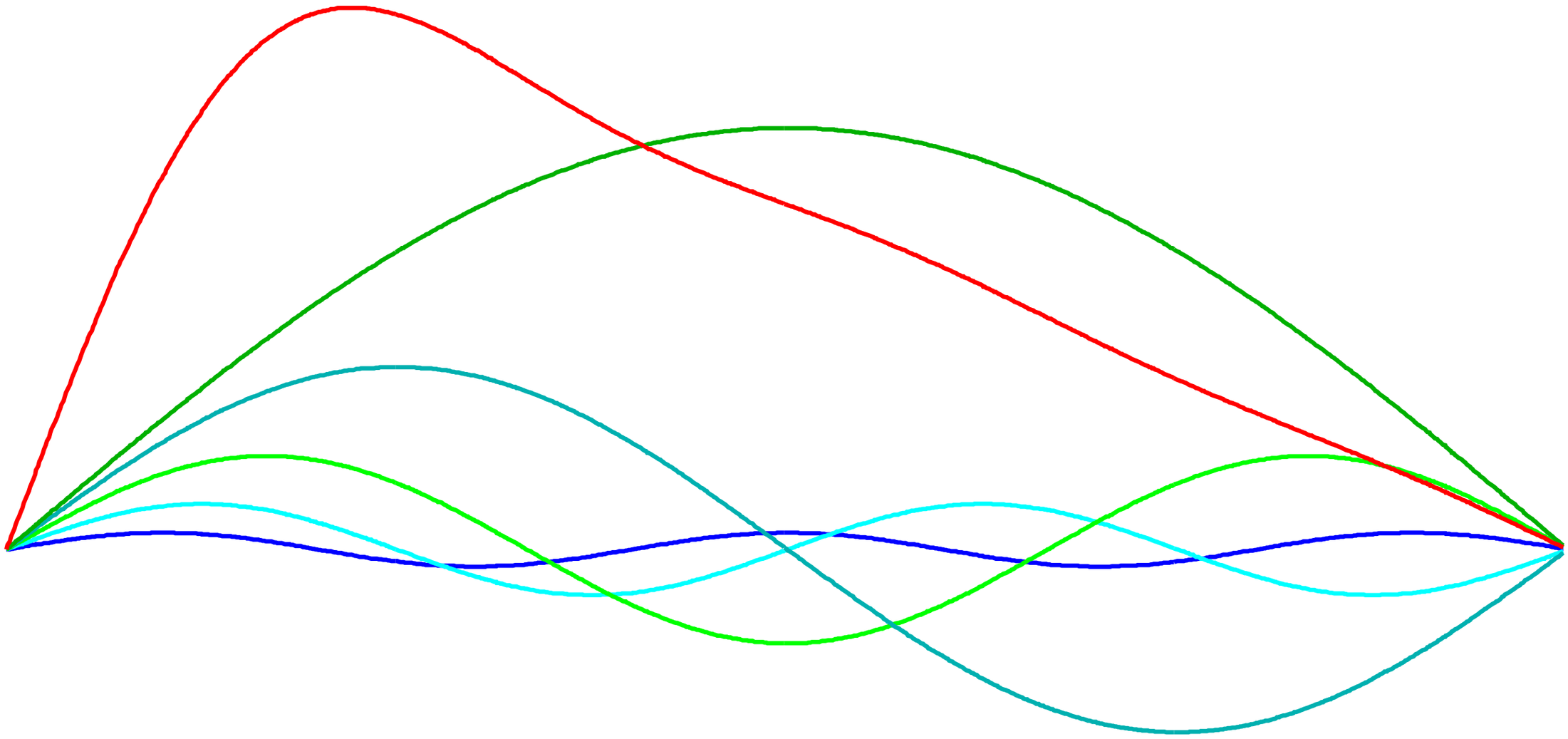


Unique shape as superposition of patterns

Unique shape as superposition of patterns



Unique shape as superposition of patterns



Unique shape as superposition of patterns

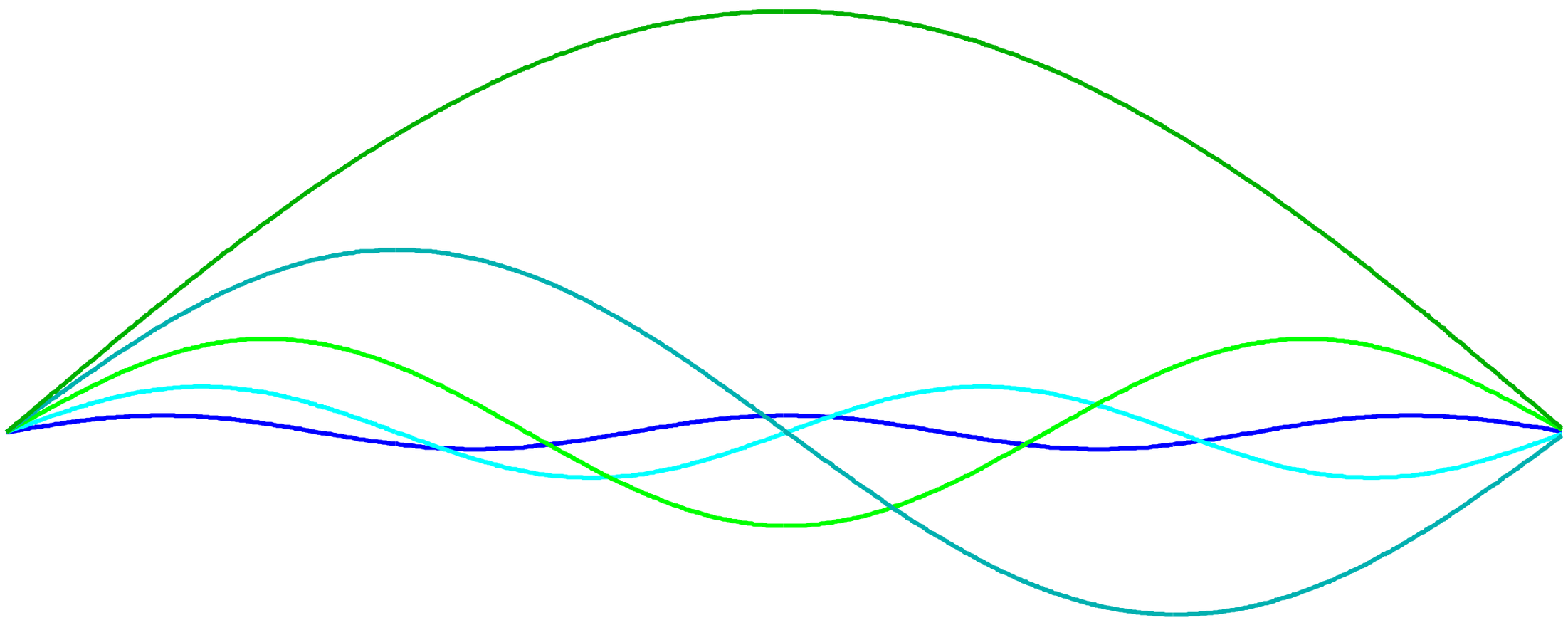


Image reconstruction

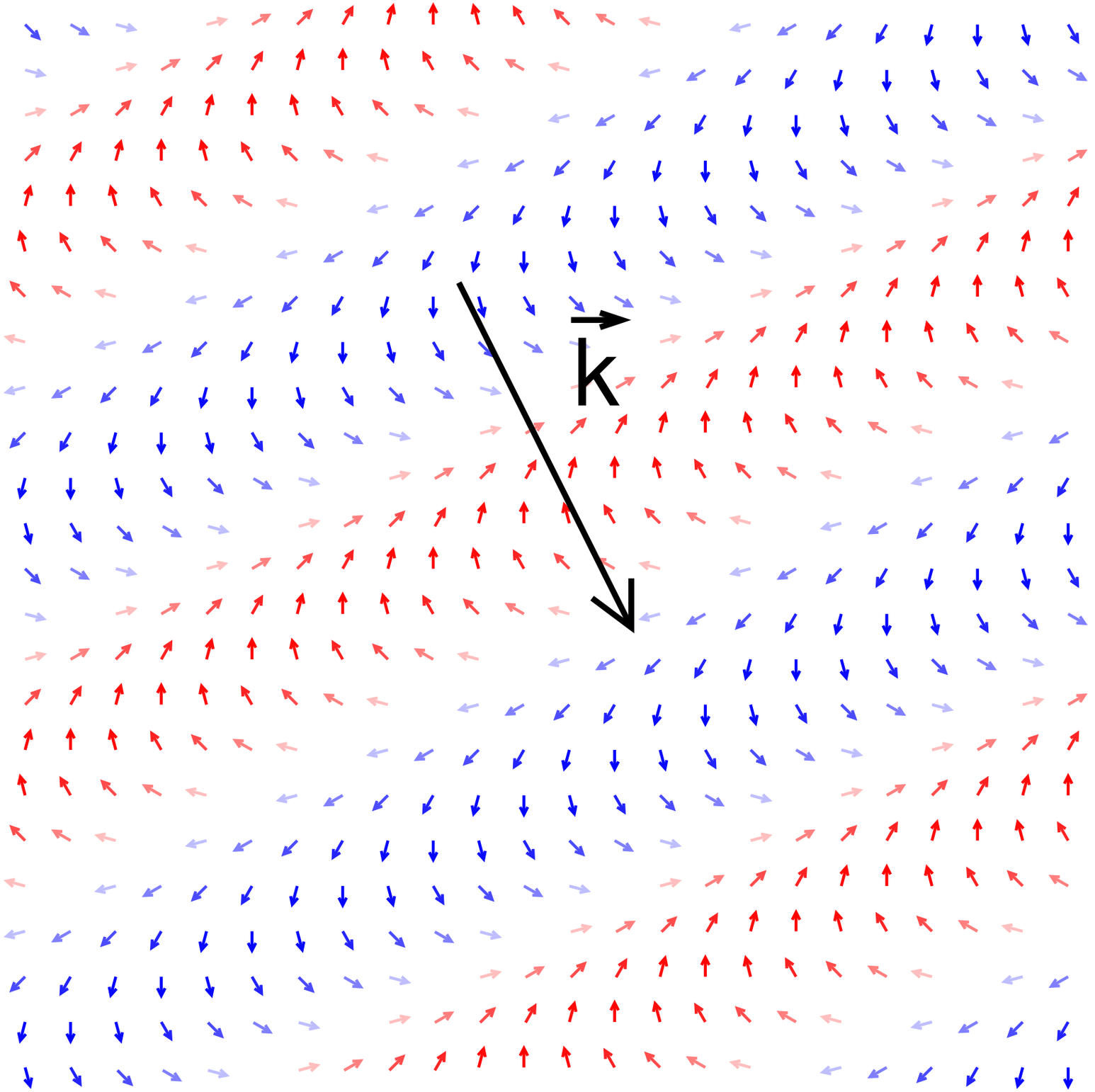
- resembles diffraction methods (crystallography)

- wavelength of the phase patterns generated by gradients

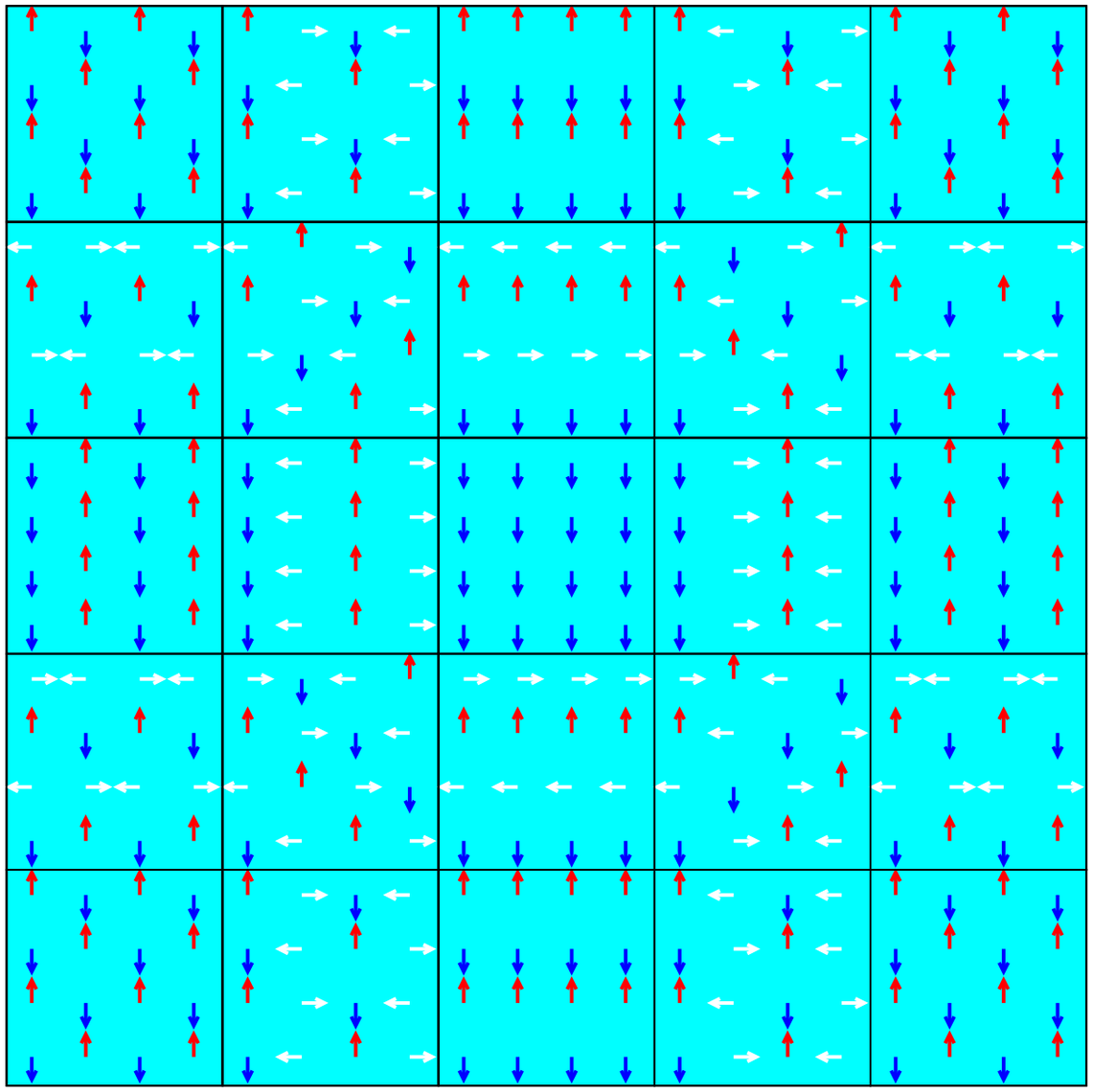
- wavelength of the radio waves is irrelevant
  (but starts to interfere at high field,
  where it approaches the body dimensions)

- Ω assumed to be identical
  differences must be corrected to avoid artifacts

k space

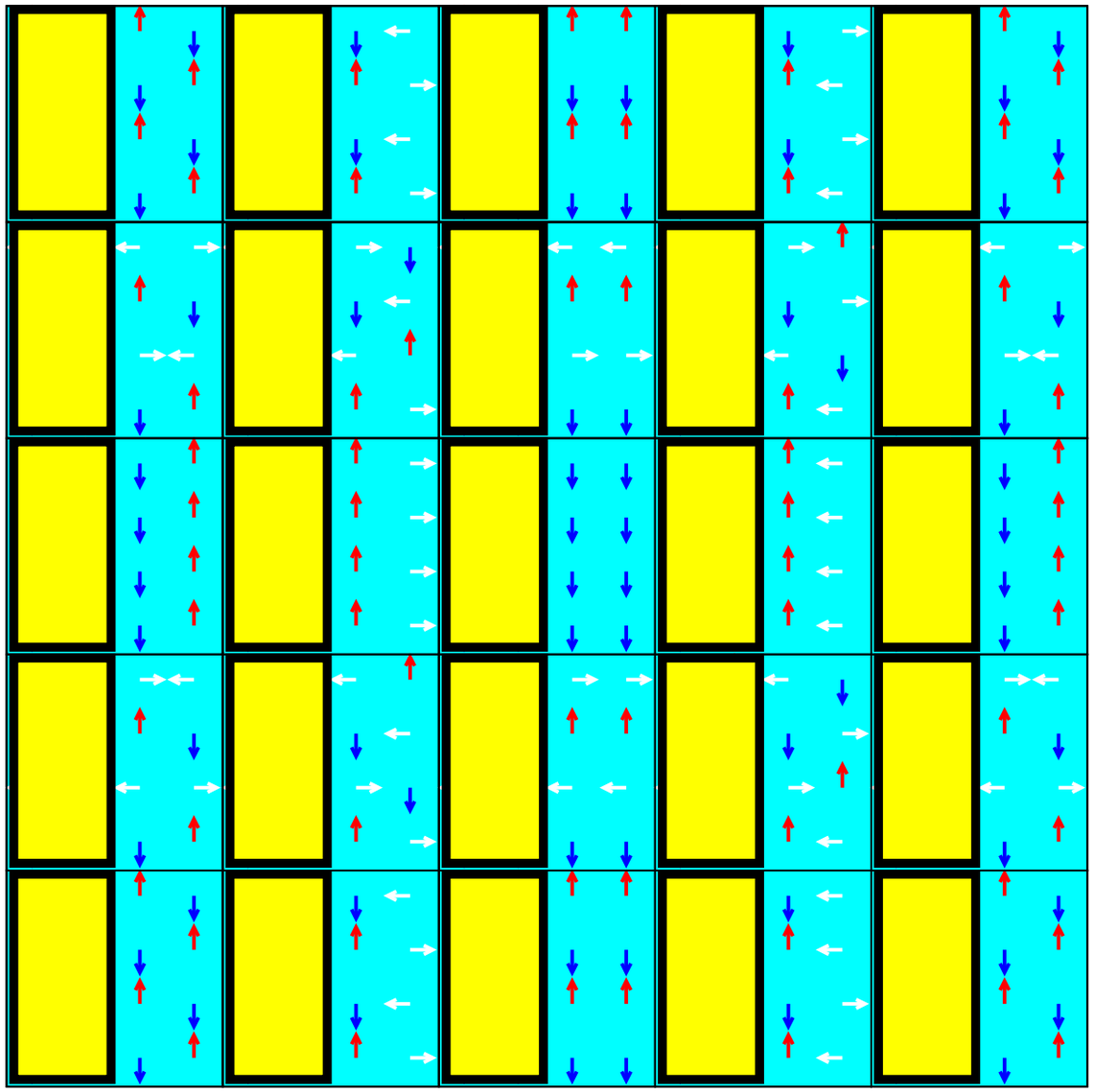


k space



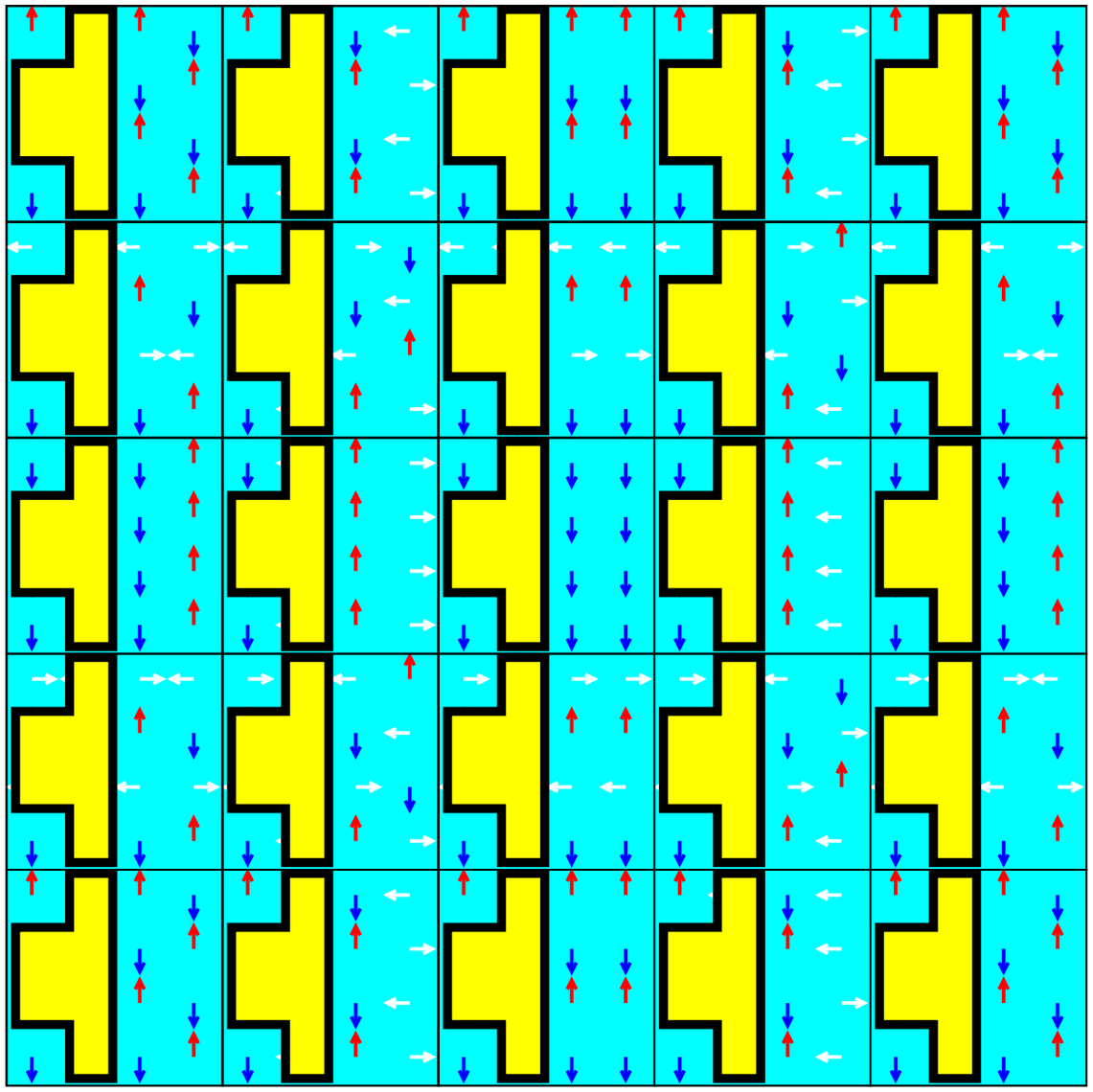
0	0	0	0	0
0	0	0	0	0
0	0	16	0	0
0	0	0	0	0
0	0	0	0	0

k space



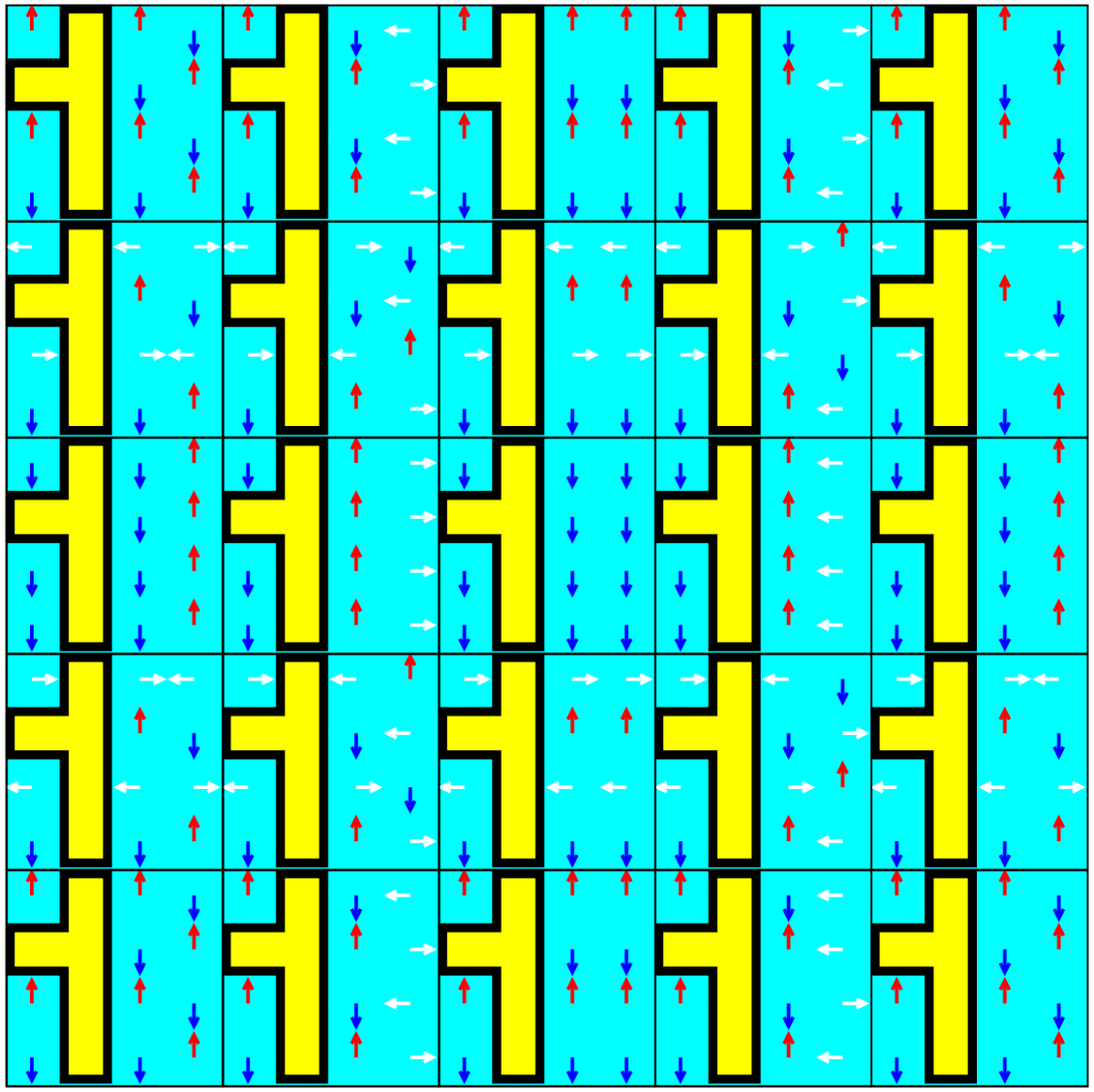
0	0	0	0	0
0	0	0	0	0
0	–4	8	–4	0
0	0	0	0	0
0	0	0	0	0

k space



0	0	0	0	0
+1	+1	+1	+1	+1
+2	−2	10	−2	+2
+1	+1	+1	+1	+1
0	0	0	0	0

k space



−1	−1	−1	−1	−1
+1	+1	+1	+1	+1
+3	−1	11	−1	+3
+1	+1	+1	+1	+1
−1	−1	−1	−1	−1

See Figure 15 in

https://eprints.drcmr.dk/37/1/MRI_English_a4.pdf