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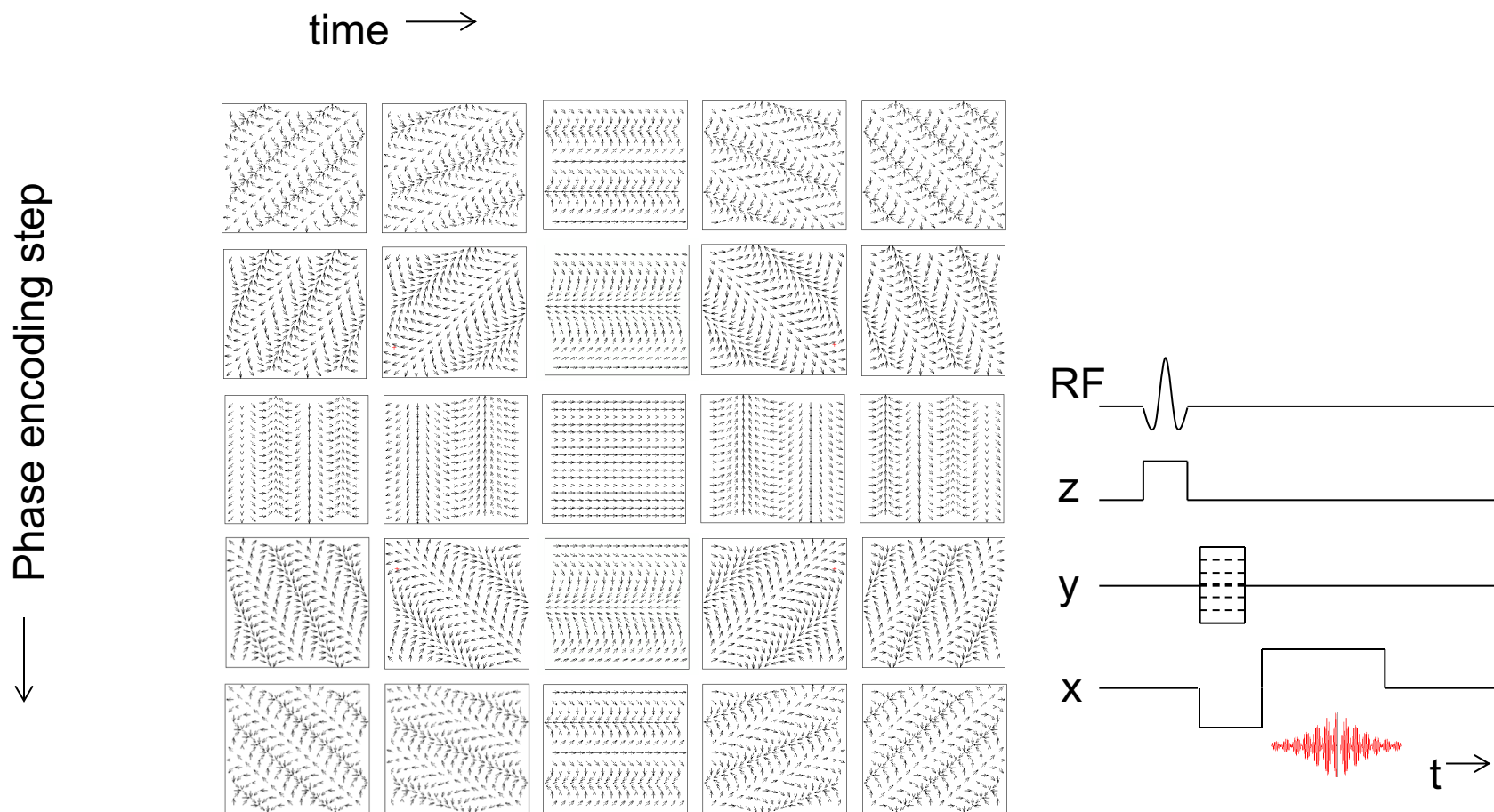
# MRI pulse sequences for neuroimaging research

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k-space

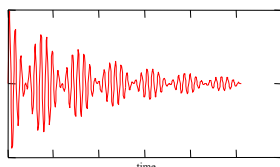
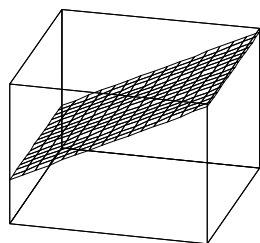
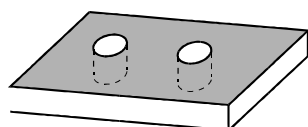


# We acquire spatial frequency information

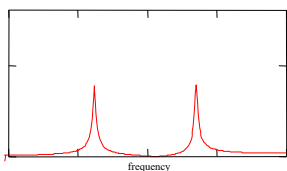




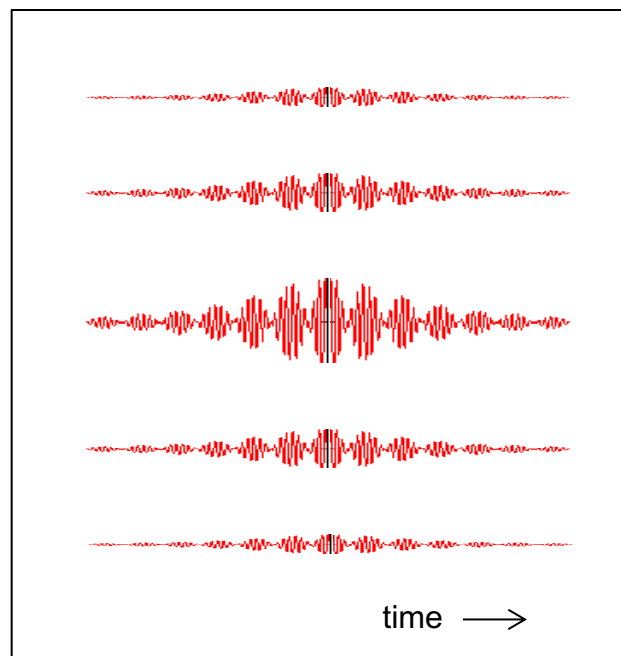
# We acquire spatial frequency information



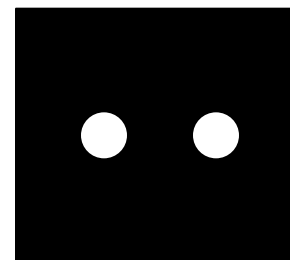
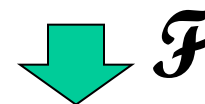
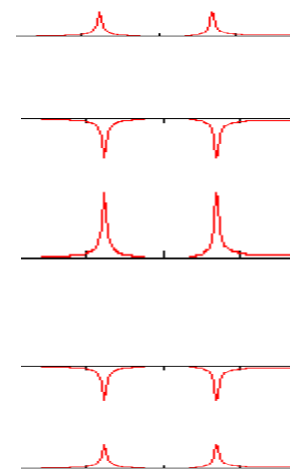
FT



Phase encoding steps  
↓



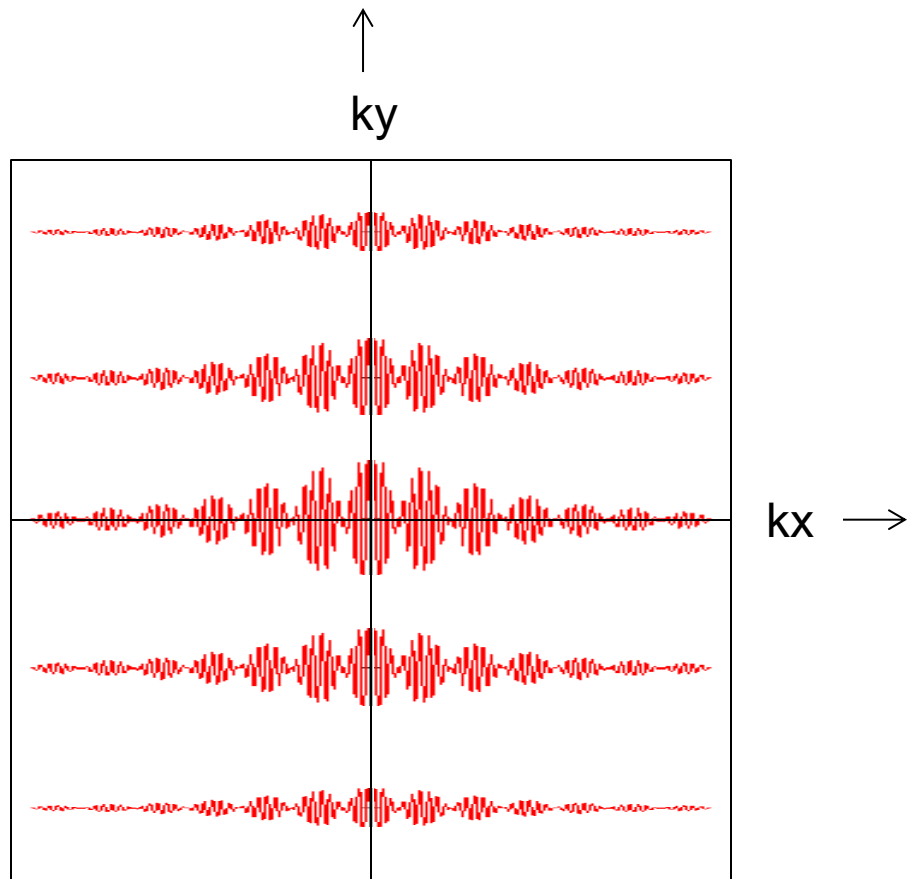
Frequency encoding →



image

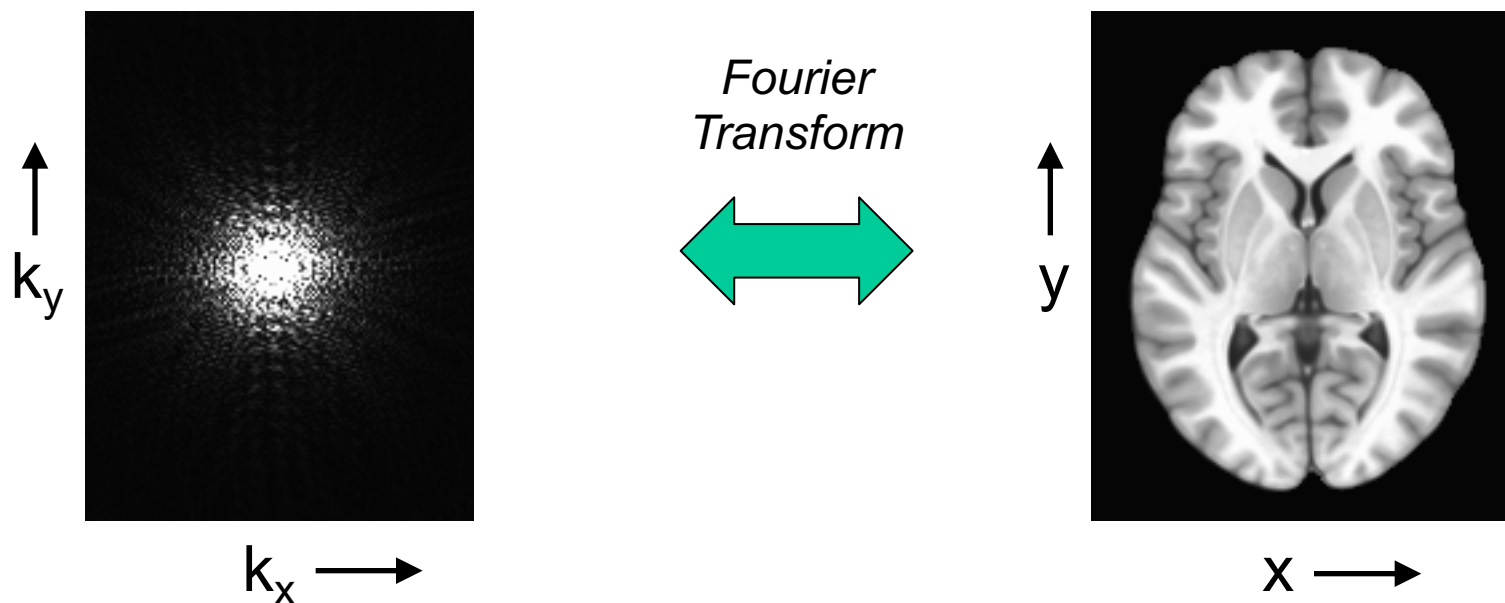


# k-space



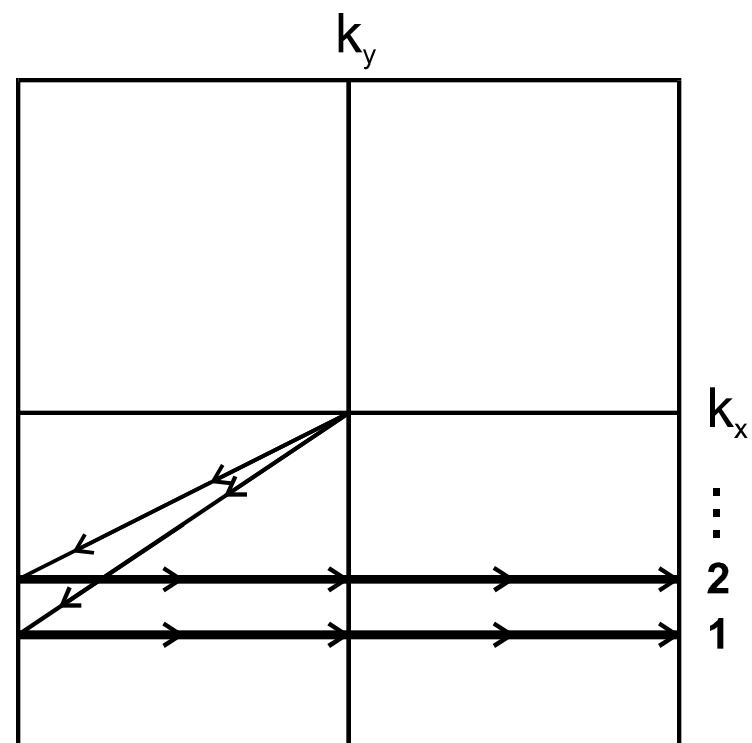
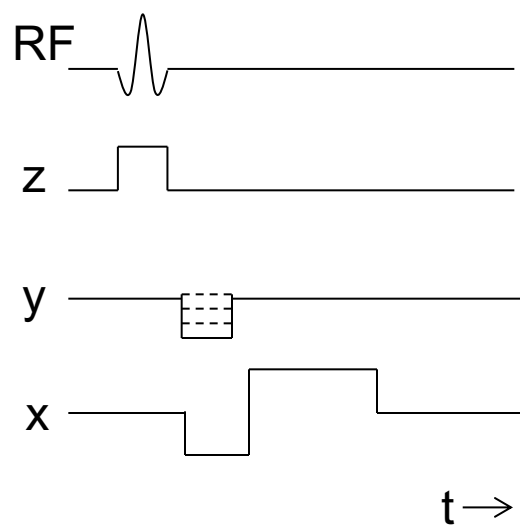


# Image (x) space vs. k-space





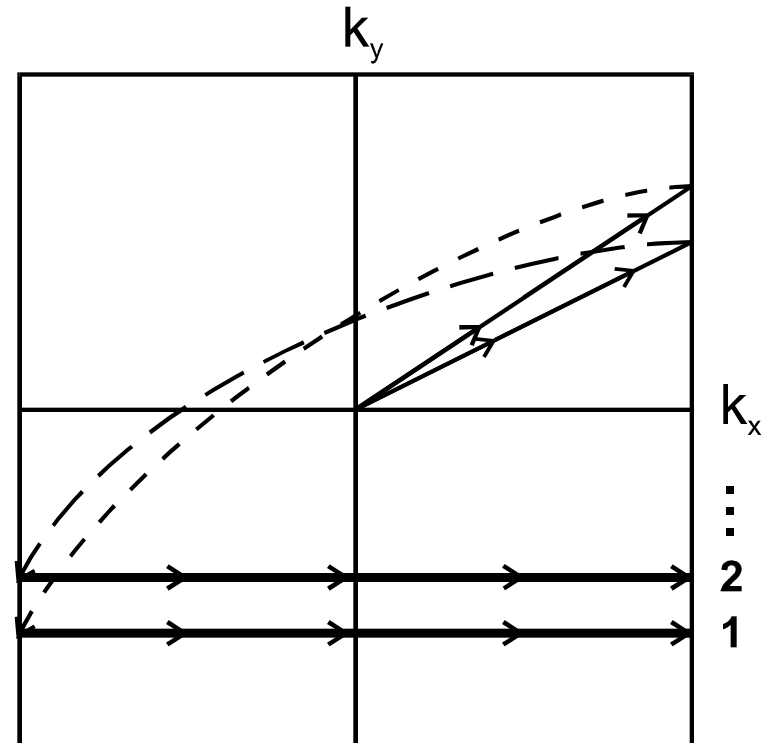
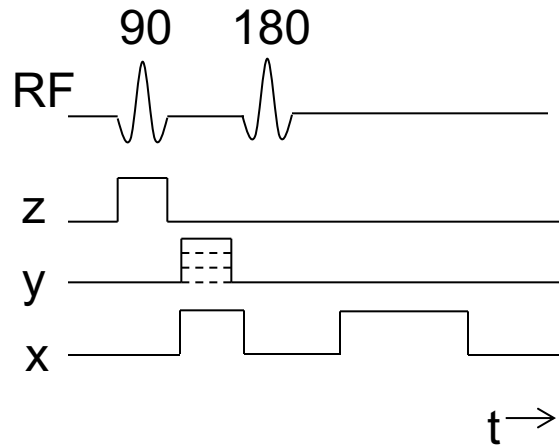
# Gradient Echo



$$k = \gamma \int G dt$$

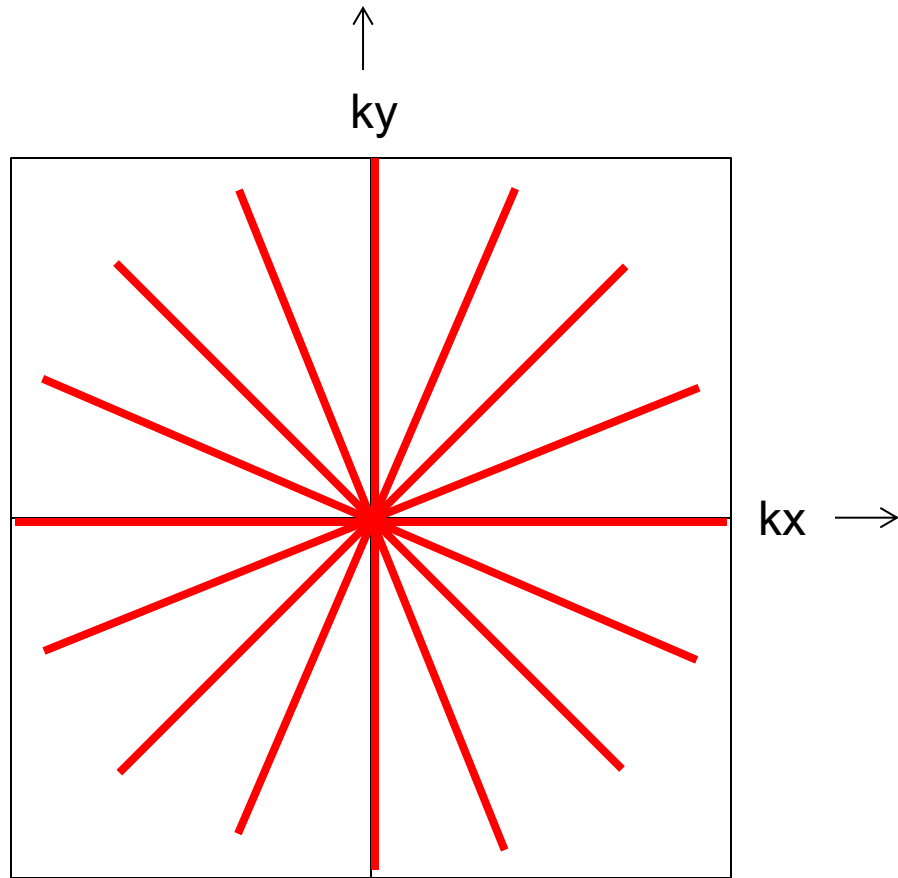


# Spin Echo



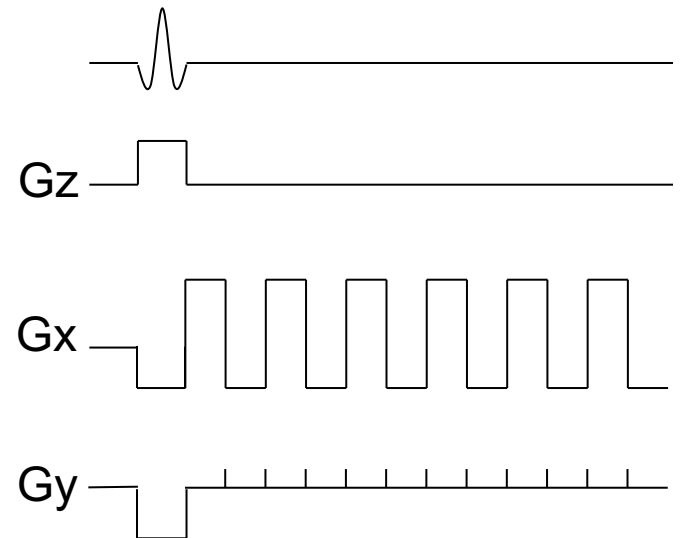
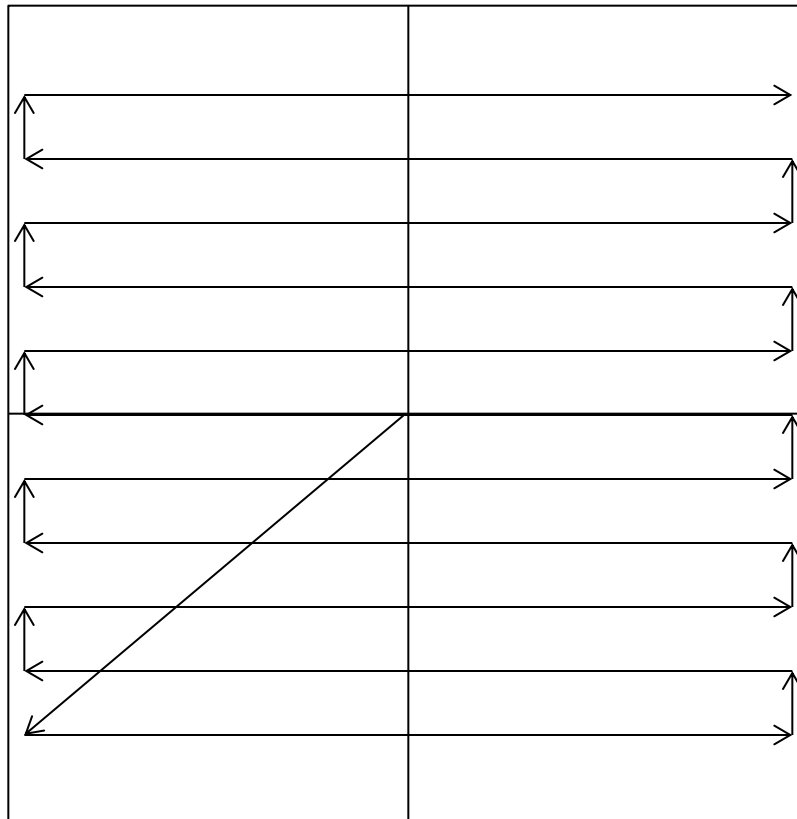


# Projection Reconstruction



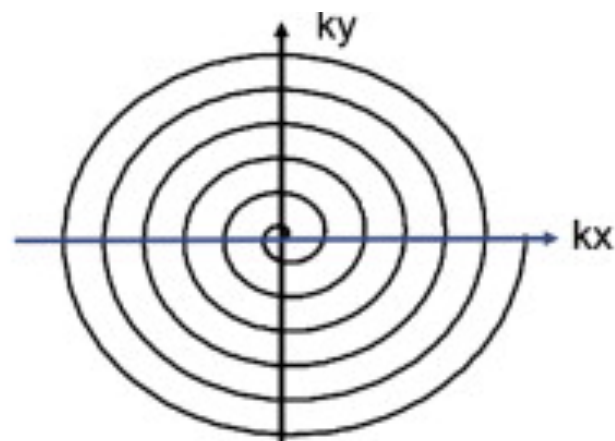
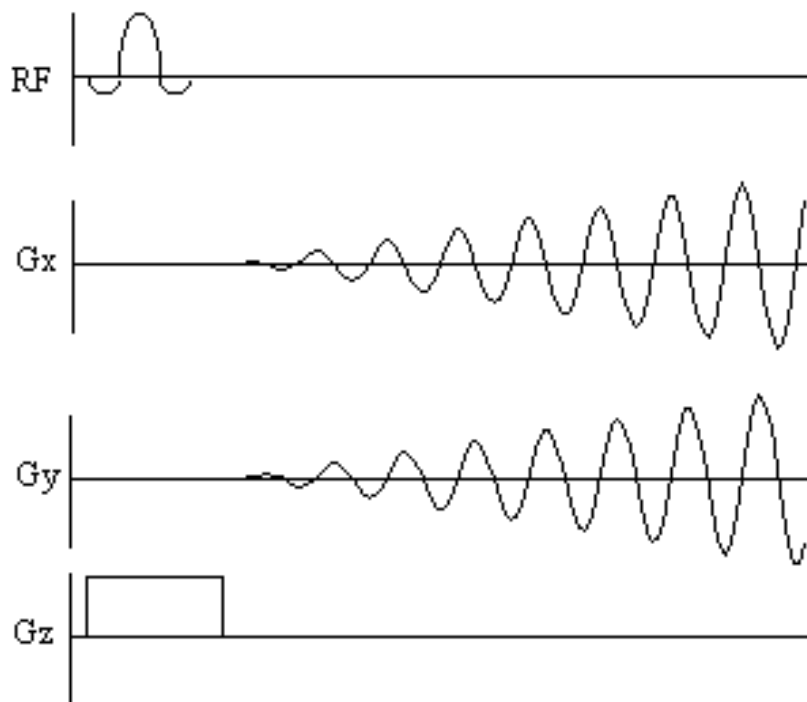


# Echo-planar imaging





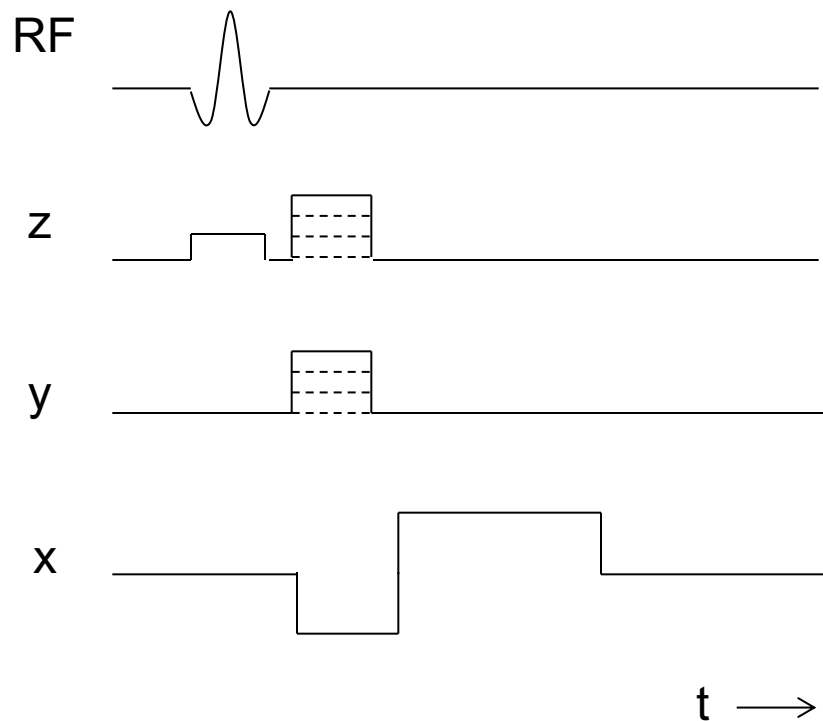
# Spiral sequence





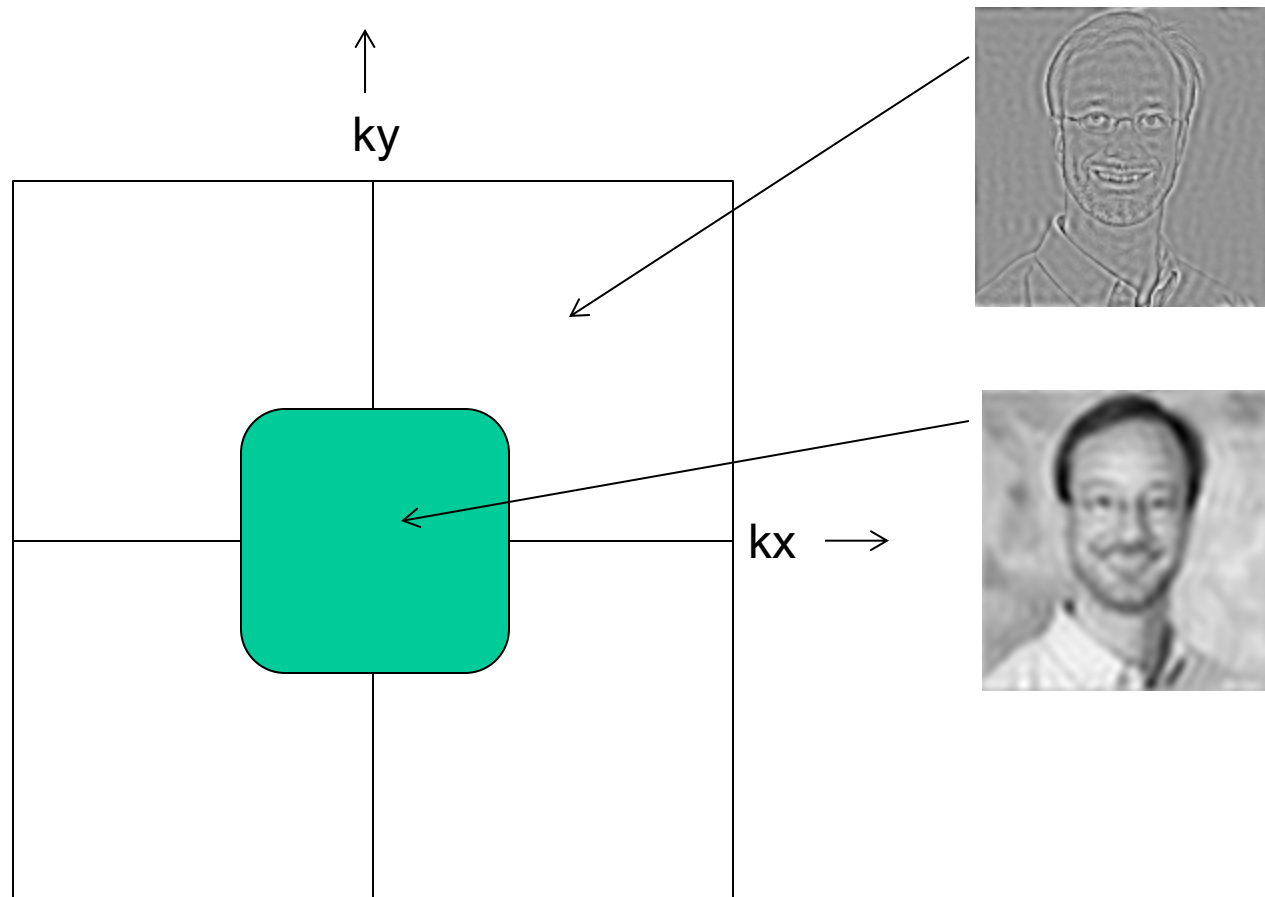
# 3d imaging sequences

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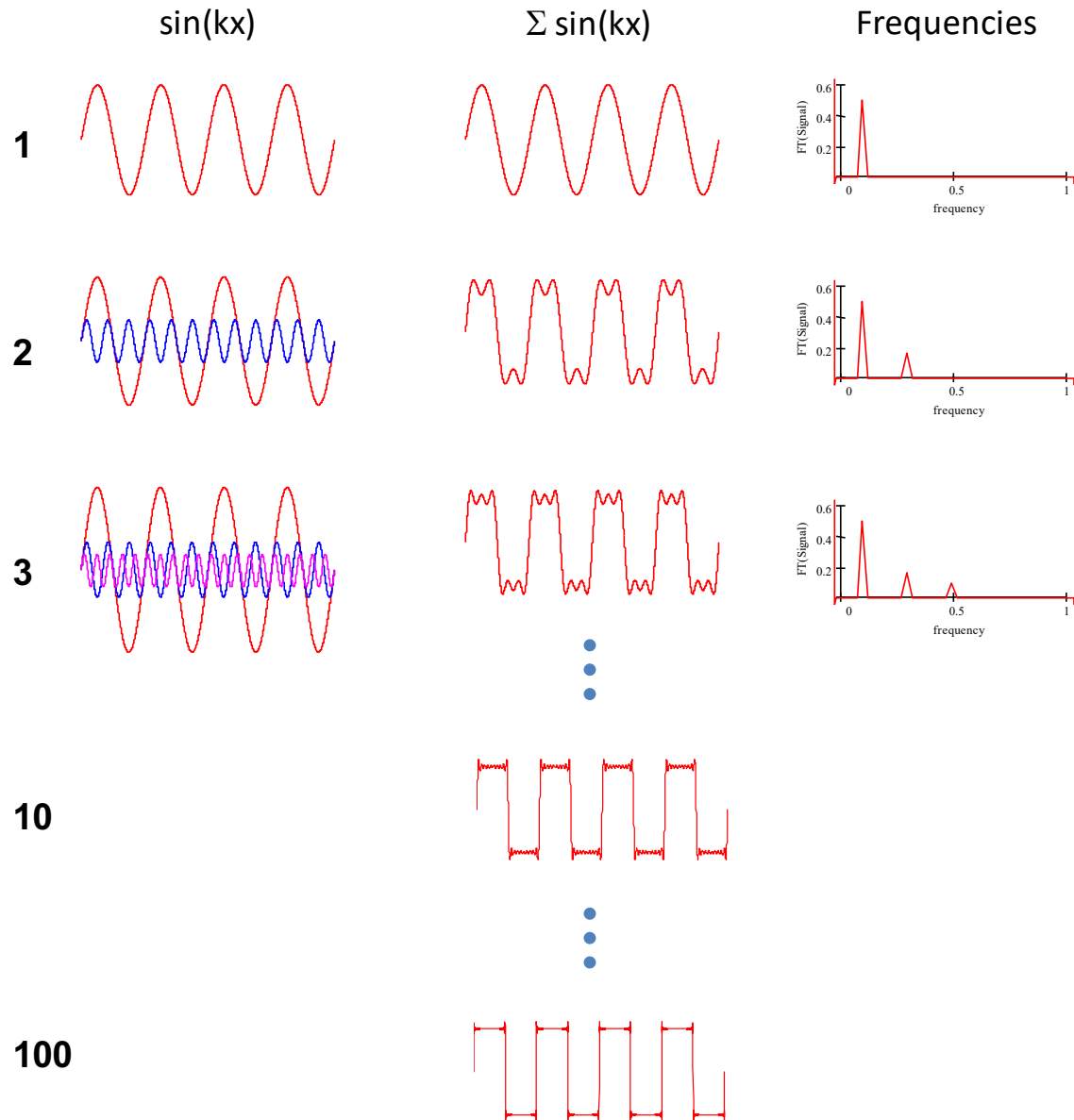


# k-space properties



# The sum of sines and cosines can create any other function.

For example,  
a *square wave*:

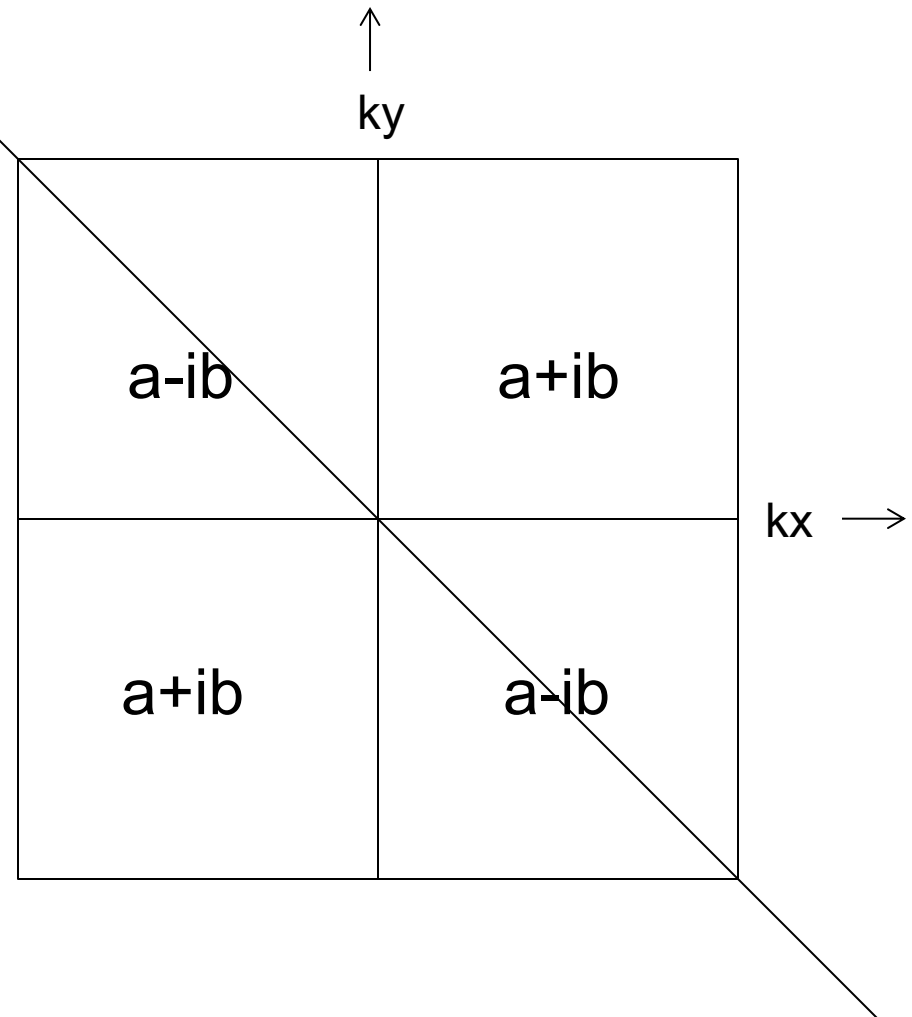
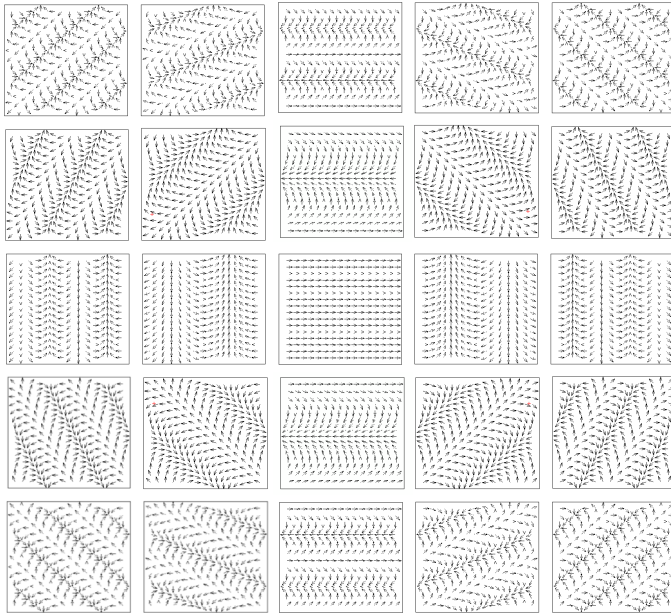


In this way, an  
object can be  
expressed as the  
sum of different  
spatial frequencies



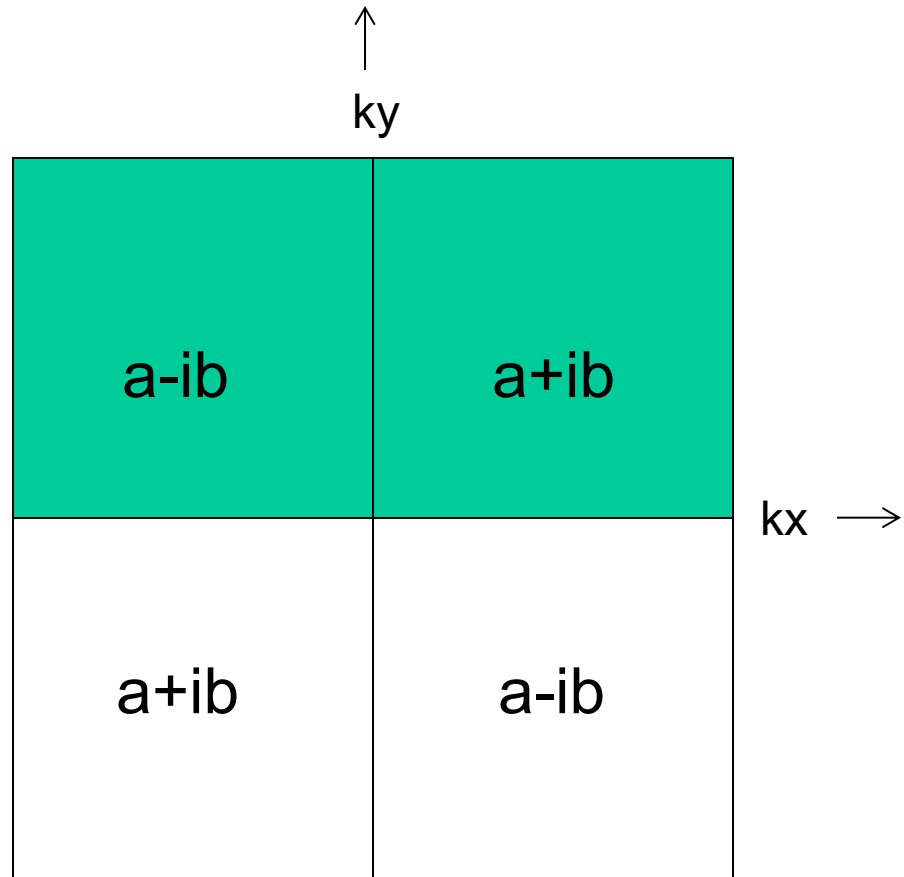
# k-space properties

## Complex conjugate symmetry



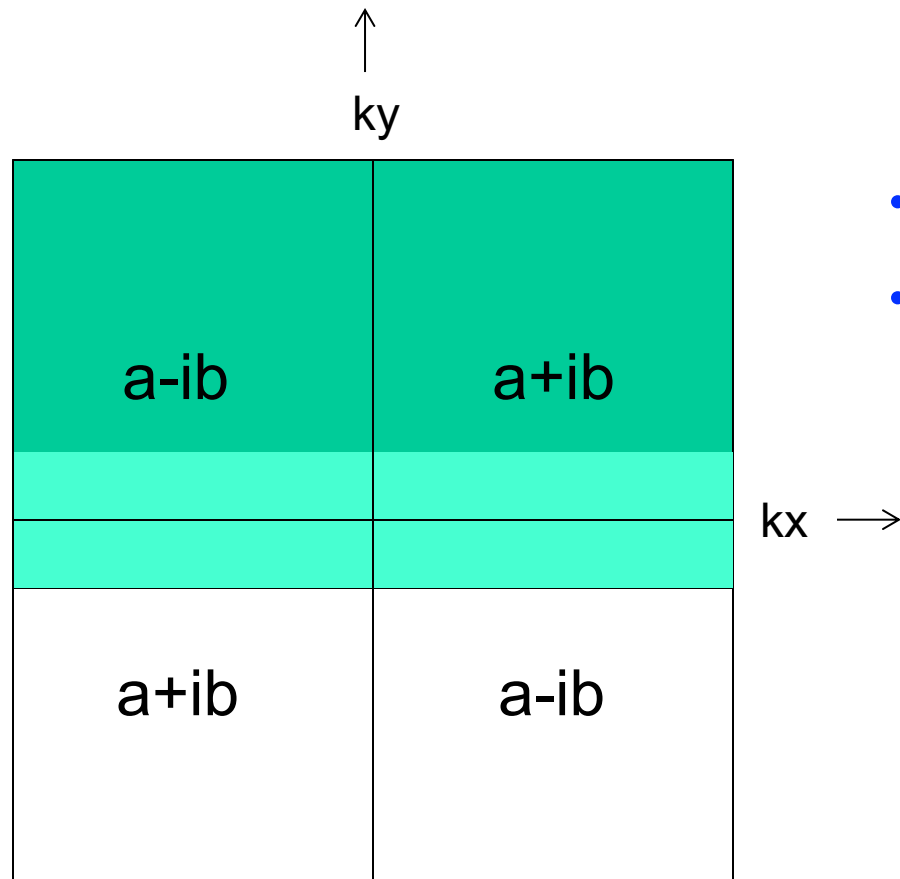


# Partial k-space

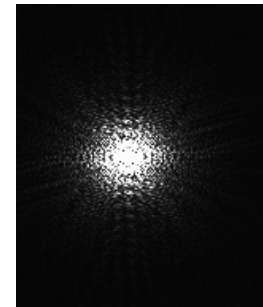




# Partial k-space



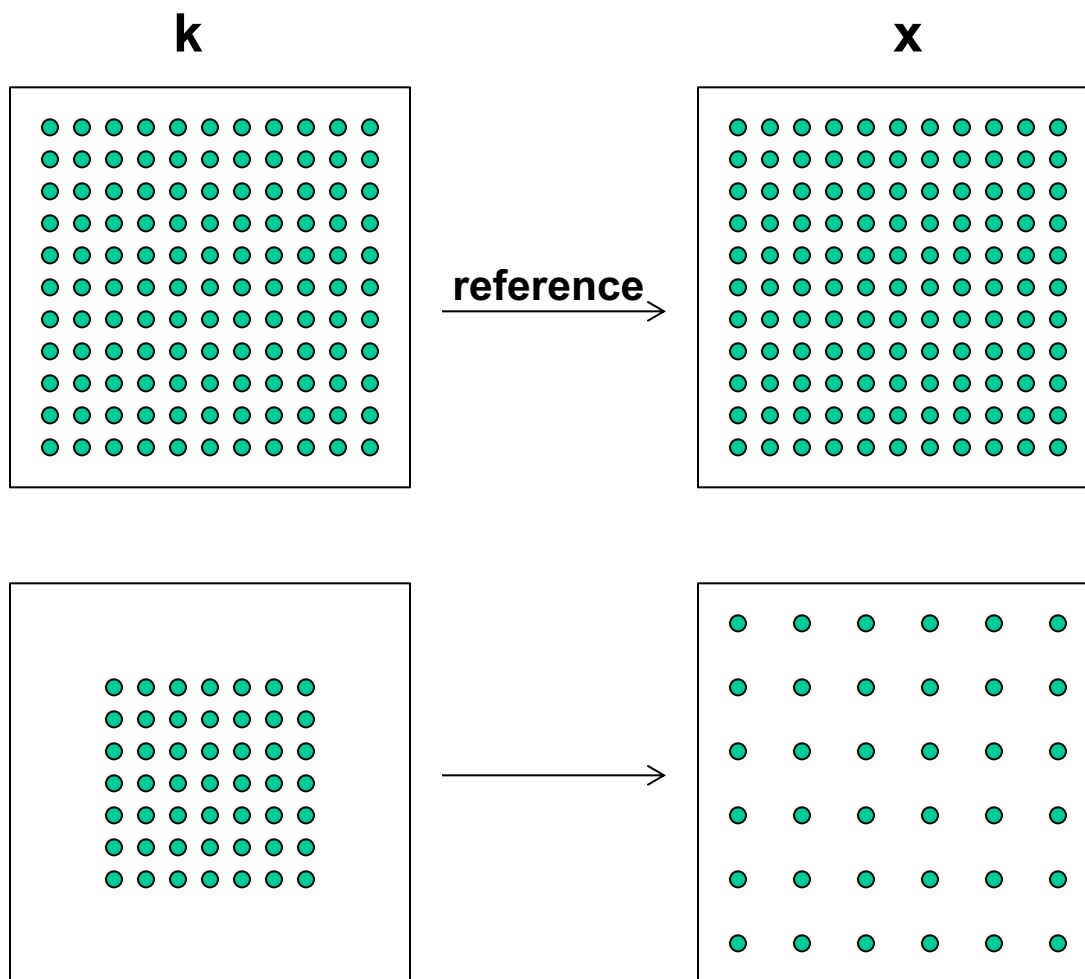
- Imaging time:  $\downarrow f$
- SNR:  $\downarrow \sqrt{f}$





# Properties of k-space

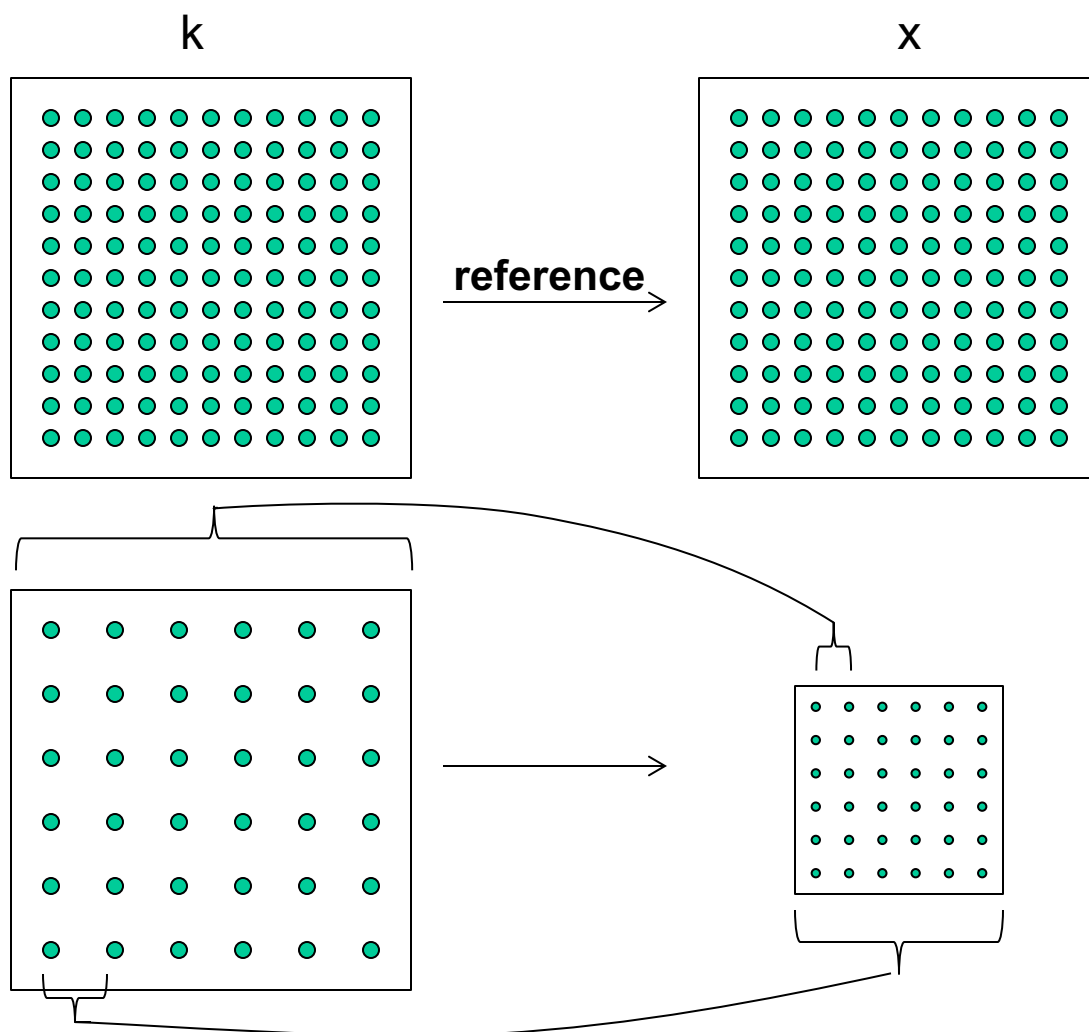
*The extent of k-space you sample determines the image resolution*





# Properties of k-space

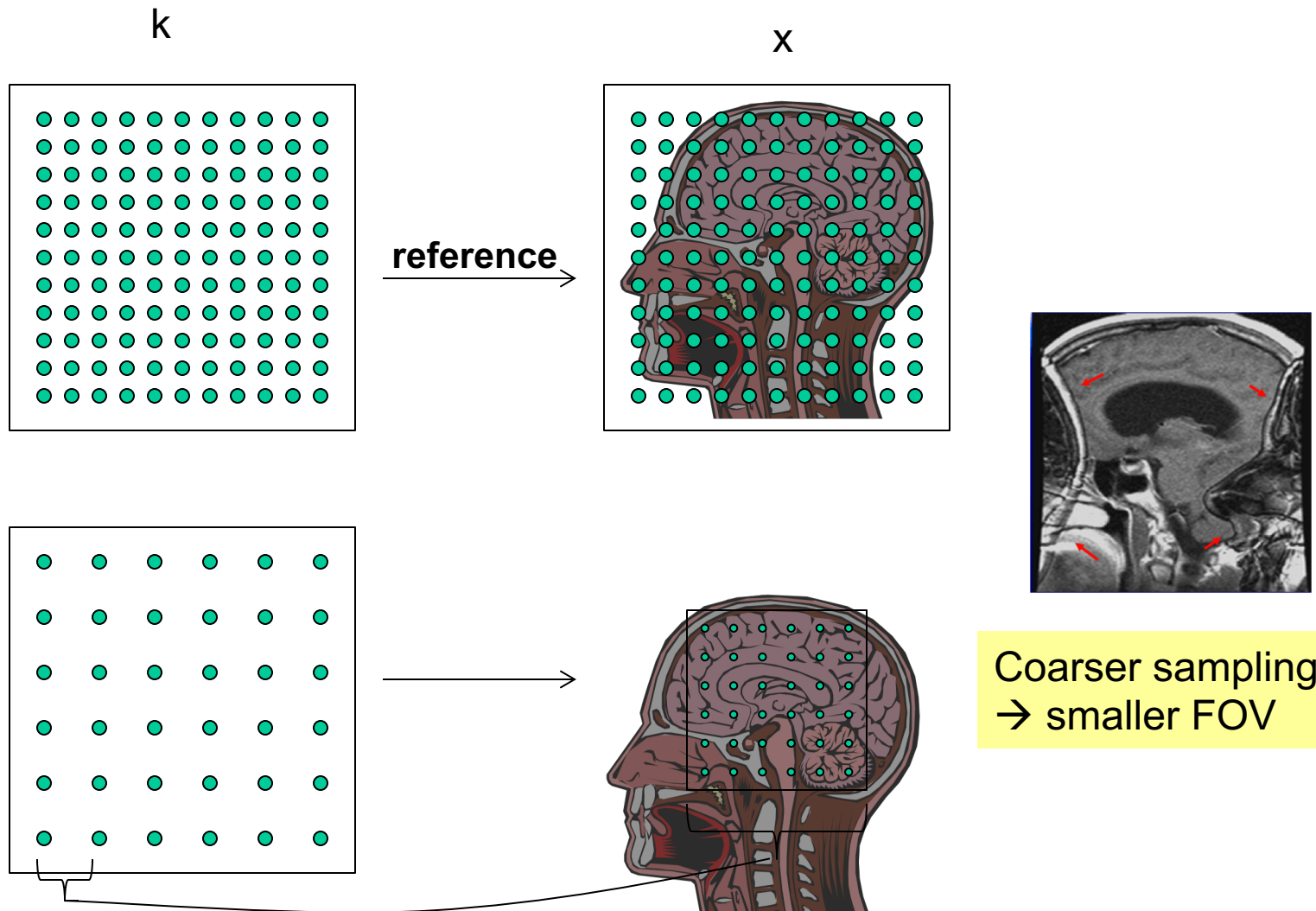
*The space between samples in k-space determines the field-of-view*



Coarser sampling  
→ smaller FOV

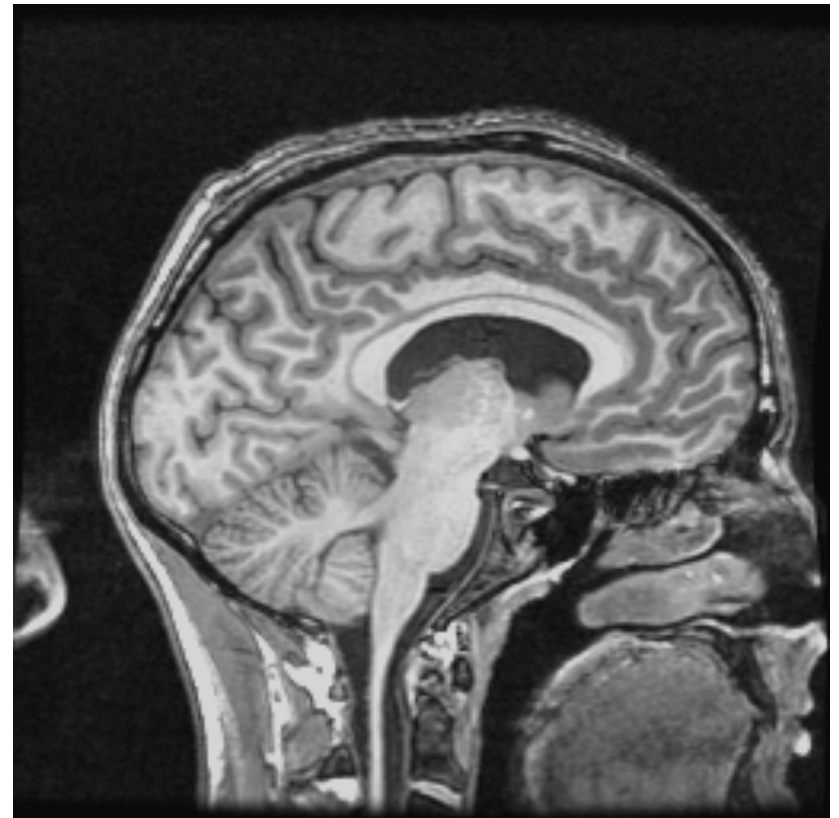
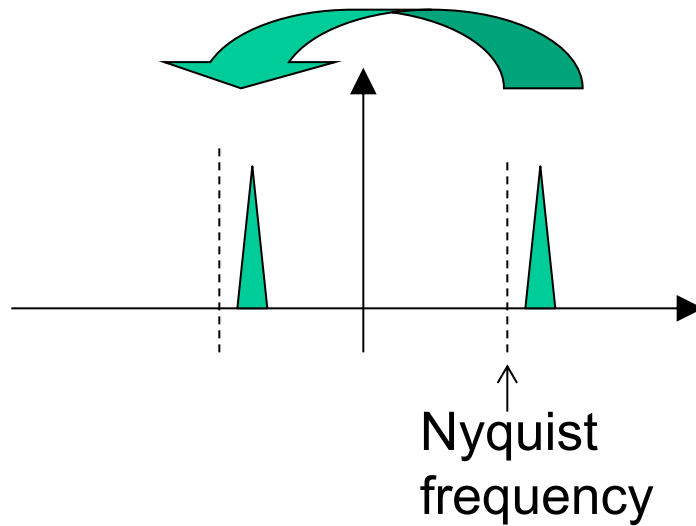
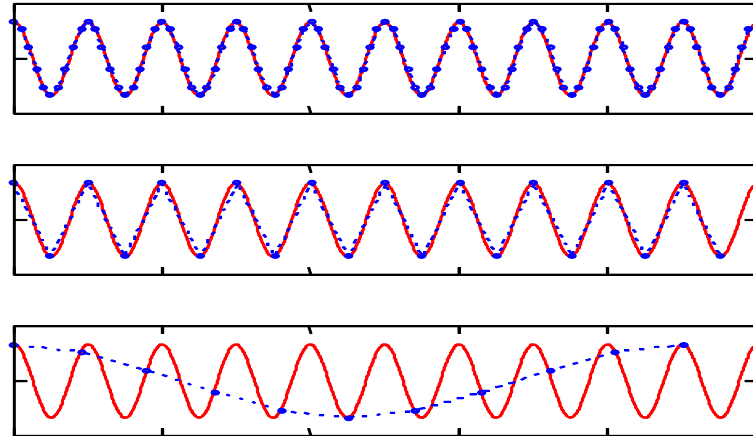


# Properties of k-space





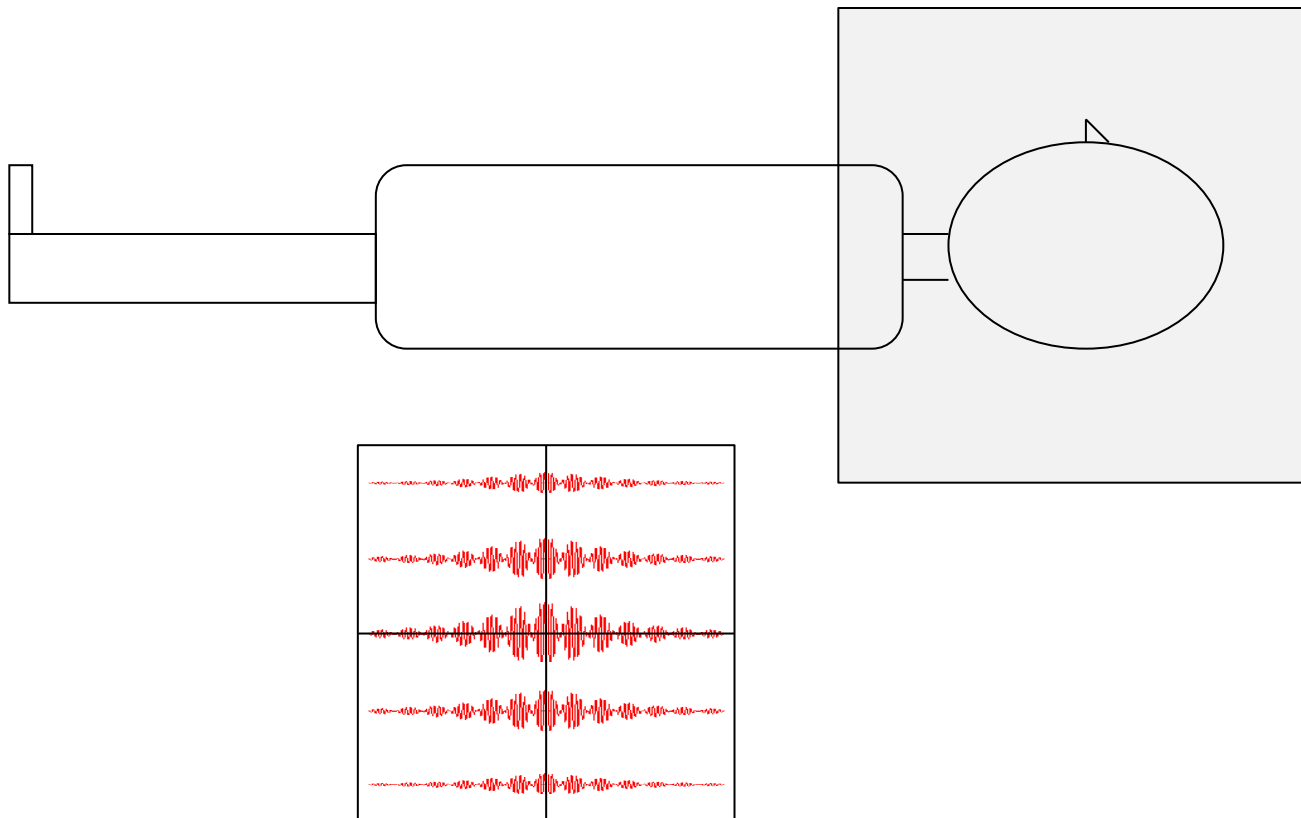
# Aliasing





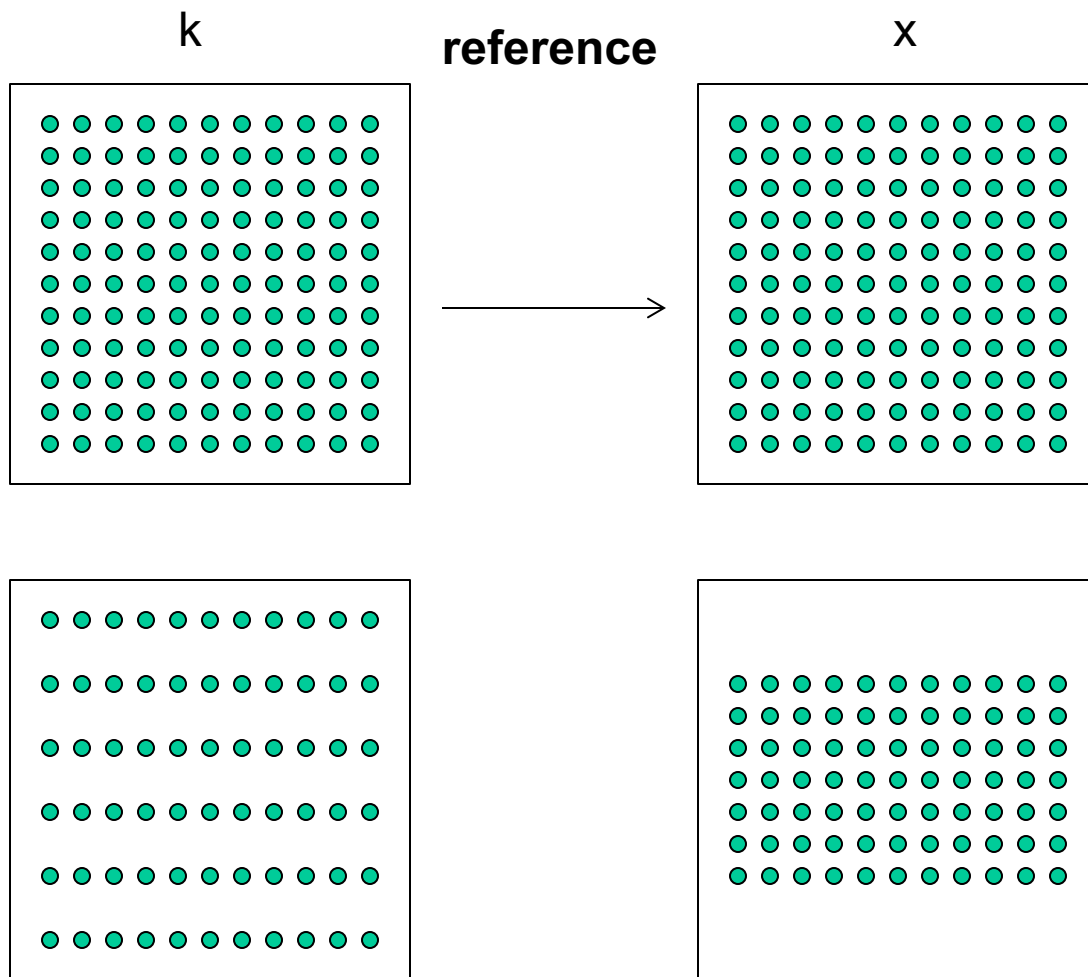
# Aliasing

Consider sagittal slice acquisition:





# Properties of k-space



Coarser sampling  
in one direction →  
smaller FOV in  
that direction