Example: Image Restoration

scene

camera

image

- Imaging system introduces distortion
  - Out of focus lens
  - Hubble telescope mirrors
  - Motion blur
  - atmospheric distortion
- Image restoration aims to reduce the distortion by post-processing the image

Model: approximate distortion with a linear shift-invariant system PSF $h[m,n]$

$$g[m,n] = h[m,n] * f[m,n]$$

observed image — "blur" PSF — "clean" image

$$\updownarrow \text{DSFT}$$

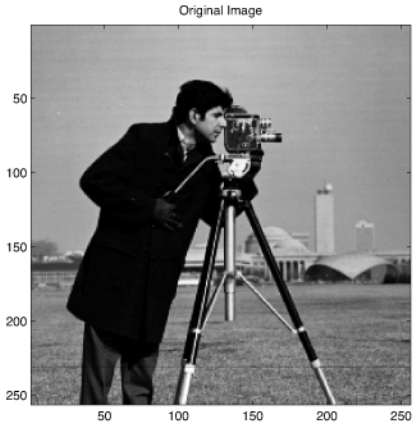
$$G(u,v) = H(u,v)\,F(u,v)$$

Given $H(u,v)$ —

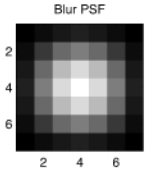
$$F(u,v) = \frac{G(u,v)}{H(u,v)} \quad \overset{\text{DSFT}}{\longleftrightarrow} \quad f[m,n]$$

Caution - watch for $H(u,v) = 0$

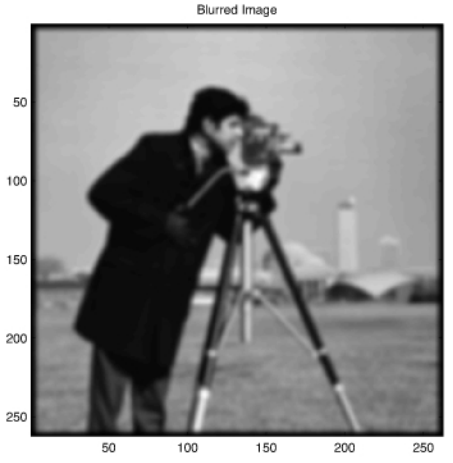
Model for Blur



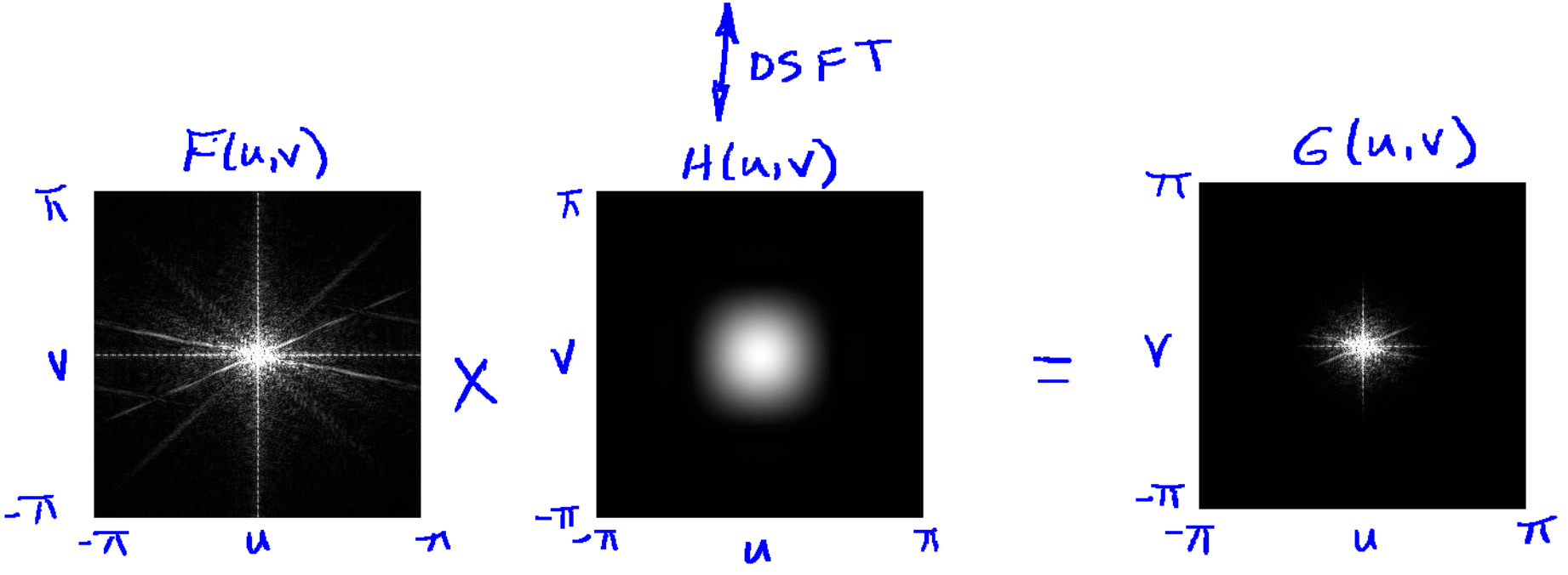
$*$



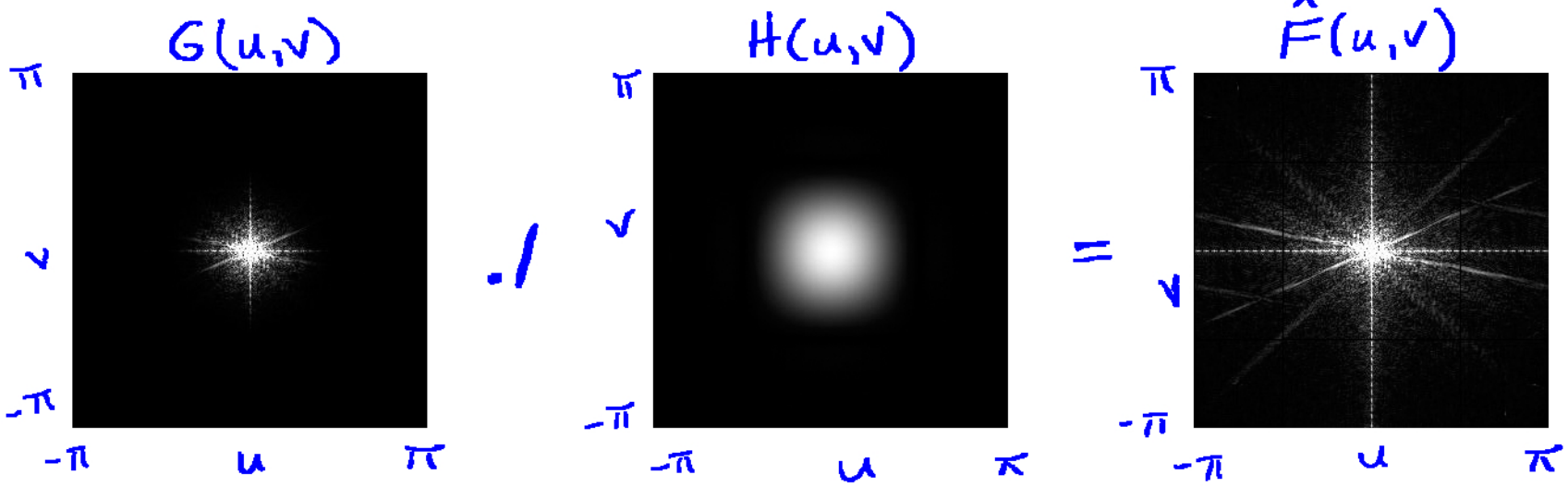
$=$



observed image

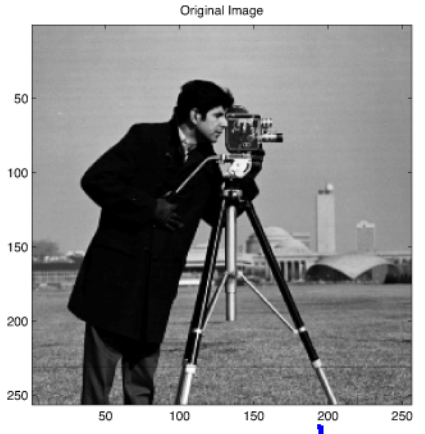


Deblurring

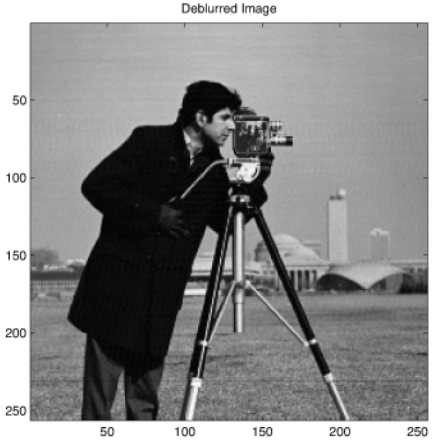


Cautions

- must know h[m,n)
- zero or small H(u,v)
- Observation noise



original



deblurred

Observation Noise

$$g[m,n] = h[m,n] * f[m,n] + w[m,n]$$

$w[m,n]$ ← noise

$$\hat{F}(u,v) = \frac{G(u,v)}{H(u,v)} = \frac{H(u,v)F(u,v)}{H(u,v)} + \frac{W(u,v)}{H(u,v)}$$

small values of $H(u,v)$ → amplify noise

limit $\frac{1}{H(u,v)}$