• Adding amplitude contrast to CTF
• Phase Plate
Contribution to CTF by real object with both phase and amplitude contrasts

Weak Phase Object

\[
sin\left( -\pi \Delta z \lambda k^2 + \frac{\pi C_s \lambda^3 k^4}{2} \right) = \sin(\gamma(k))
\]

Weak Amplitude Object

\[
\cos(\gamma(k))
\]

TOGETHER:

\[
A \cos(\gamma(k)) + \sqrt{1-A^2} \sin(\gamma(k)) = \sin(\gamma(k) + \alpha)
\]

Amplitude contrast coefficient
What do we want from phase plate?

Phase Contrast

\[
\sin(\gamma(k)) + \text{Amplitude Contrast} \sin(\gamma(k) + \alpha)
\]

+ Phase Plate

\[
\sin(\gamma(k) + \alpha + \varphi)
\]
TEM imaging modes AND Various PP Designs

Electrostatic Phase Plate

R. Glaeser

Zernike Phase Plate

K. Nagayama

Modified from slides by Radostin Danev
Contrast development

$\Delta z = 0.5 \mu m$ (underfocus)

No Phase Plate

$\phi = 35^\circ$

$\phi = 70^\circ$

$\Delta z = 2 \mu m$
Where will we benefit from phase plate?

- Anything-
  - Pro: Low resolution contrast makes it easier to align particles with different orientation.
  - Con: Slower data acquisition with more uncertainty of device behavior

- Small molecules
  - Allow low defocus to be used that reduces the dampening effect of the envelop function.

\[ \Delta z = 2 \, \mu m \]

\[ \Delta z = 0.5 \, \mu m \]
Further readings

- **Phase Plate** –
  - Radostin Danev et. al. Using the Volta phase plate with defocus for cryo-EM single particle analysis. eLife 2017;10.7554/eLife.23006

- **Amplitude contrast coefficient values** –