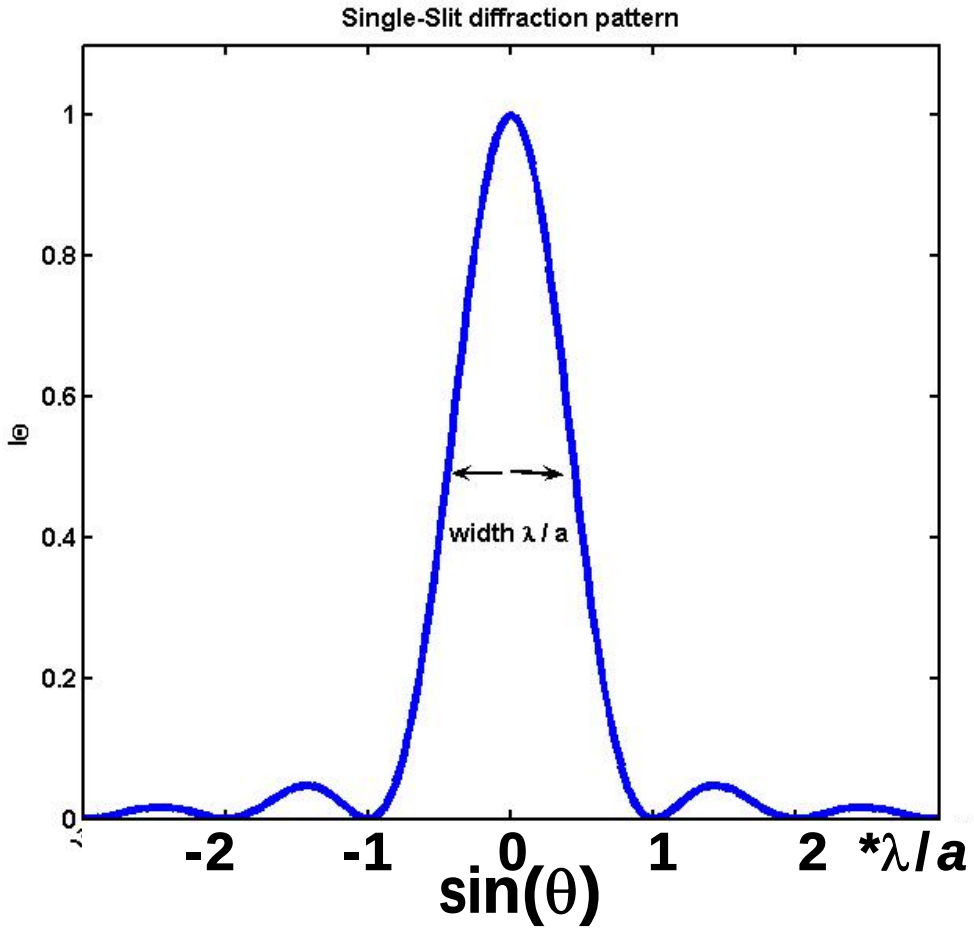
Phys. 352: diffraction

Diffraction from a single slit of width *a*, at wavelength λ:

$$I(\theta)\left(\frac{\sin\beta}{\beta}\right)^2 , \quad \beta = \frac{\pi a}{\lambda}\sin\theta$$

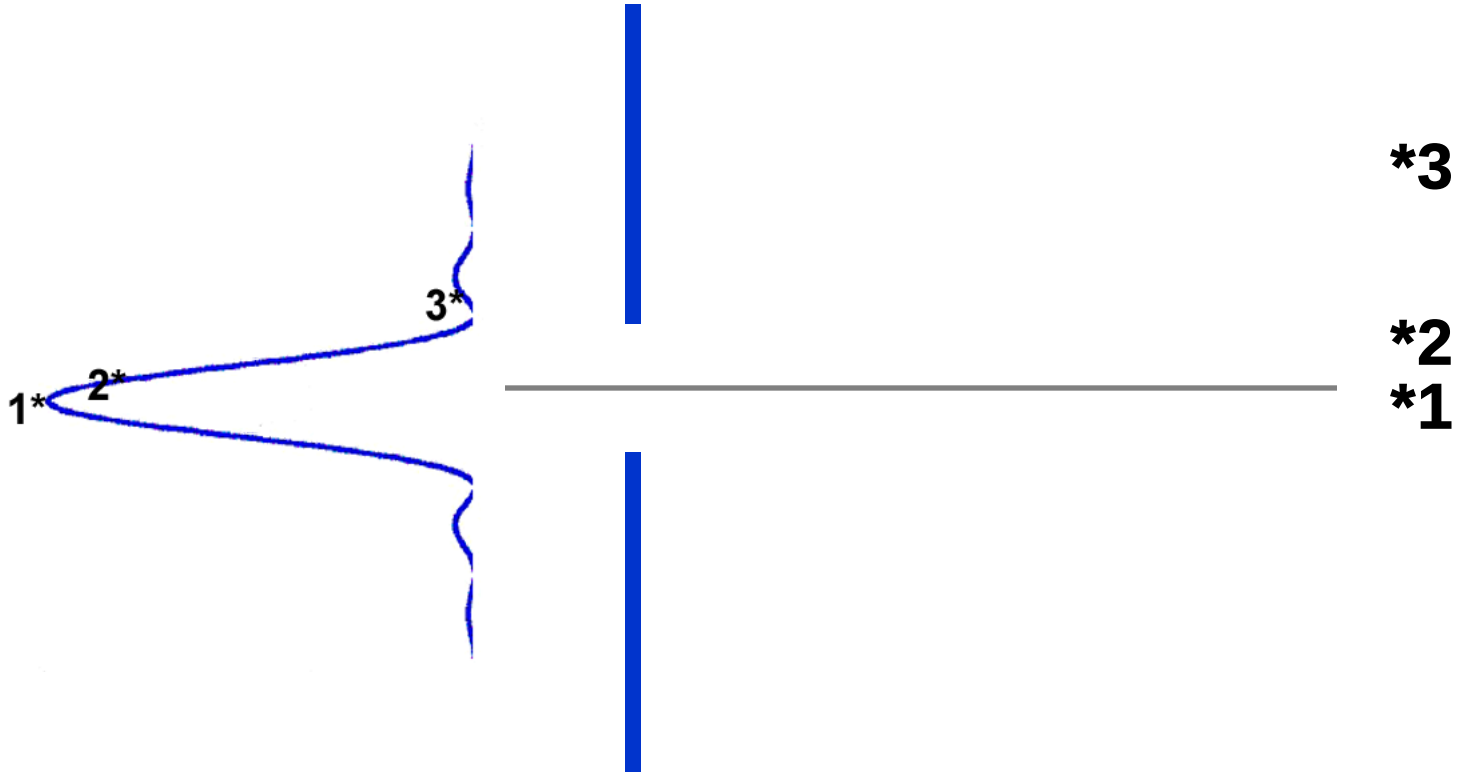


Resolution:

λ/*a* is also the angular resolution of the slit, or any aperture, when used for imaging objects. Any point is blurred by ≈λ/a; points separated by less than λ/a in angle are part of the same blur, and are not resolvable.

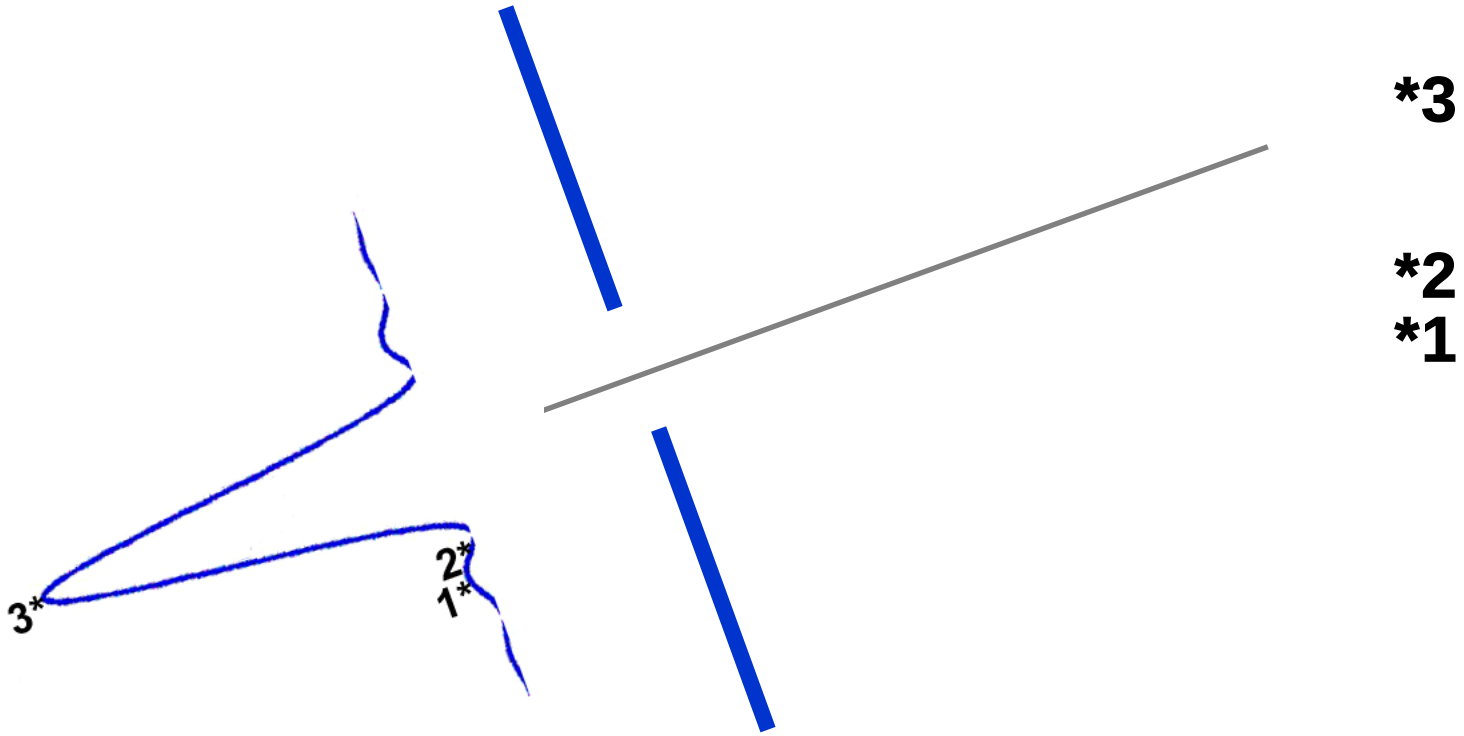
Phys. 352: diffraction

Objects 1 and 2 are not resolvable; 1 and 3 *are*



Phys. 352: diffraction

Objects 1 and 2 are not resolvable; 1 and 3 *are*



Phys. 352: diffraction

Angular resolution

Points separated by less than λ/a in angle are part of the same blur, and are not resolvable.

(FYI: The more precise Rayleigh Criterion for a circular aperture of diameter a:

The angular resolution $\theta_r = 1.22\,\lambda/a$.)

Phys. 352: diffraction

Bigger diameter (*a*) → Better (smaller) angular resolution – a reason to build large telescopes.

What if you can't build a larger telescope?

Build several and combine their signals as if they were part of one giant telescope. Interferometry: telescopes with baseline (separation) *b* acting as one telescope with aperture *a* = *b*. (Typically radio telescopes.)

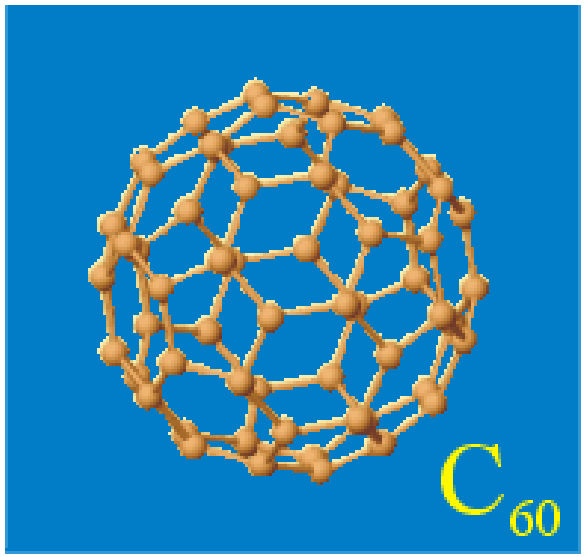
Phys. 352: diffraction

The "Very Large Array", made of 27 radio telescopes in New Mexico. Each antenna has a diameter of 25m, and the complete array has an effective baseline of 22 km.

Phys. 352: diffraction

Diffraction of matter

Phys. 352: diffraction



Diameter 1 nm.

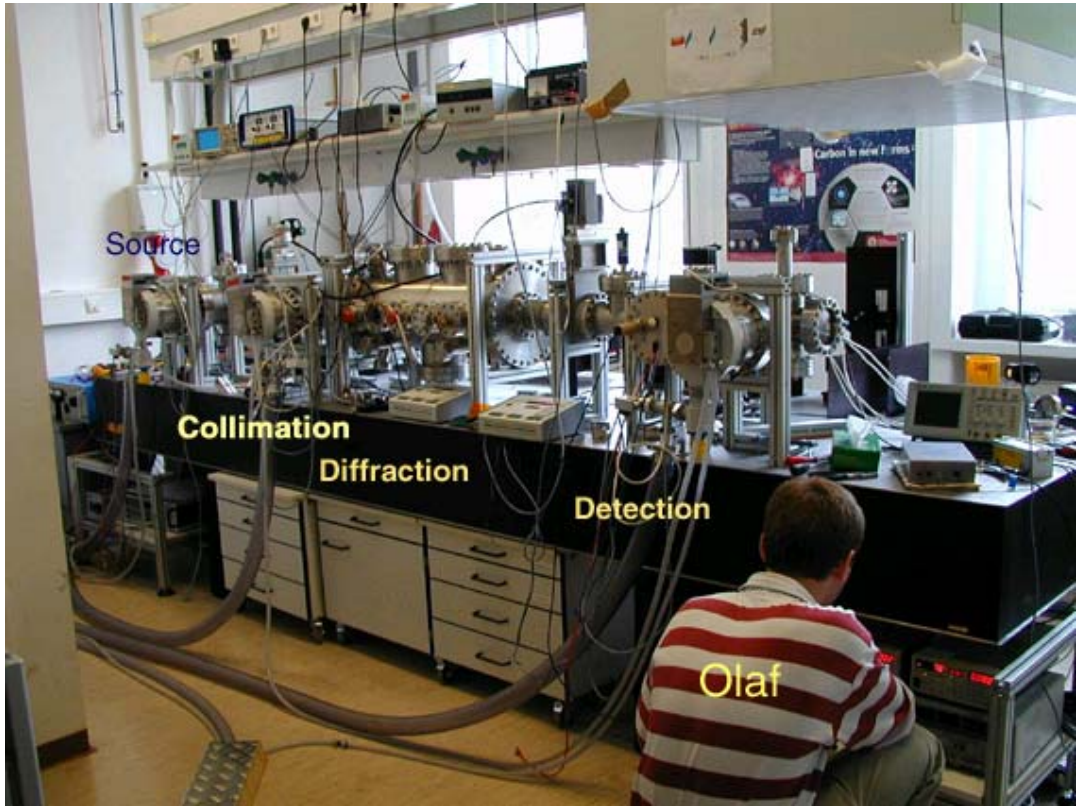
(from *http://www.quantum.at/research/matterwave/c60/index.html*)

Diffraction of C_{60}:
"Wave-particle duality of C_{60}" Markus Arndt *et al.*
Nature **401,** 680-682, 14 October 1999.

Phys. 352: diffraction

Diffraction of C60:
"Wave-particle duality of C60" Markus Arndt *et al*. *Nature* **401,** 680-682, 14 October 1999.

C_{60} molecular beam; grating with D = 100 nm.



Phys. 352: diffraction

Diffraction of C60:
"Wave-particle duality of C60" Markus Arndt *et al*. *Nature* **401,** 680-682, 14 October 1999.

The angular position of the first diffraction peak is 25 μrad; C_{60} wavelength is therefore 2.5 pm – 400x smaller than its diameter.