

Fun with interferometry

The image displays a highly detailed astronomical interferometry result. It features a complex, fibrous structure of bright, golden-yellow and white filaments against a dark, textured background. The filaments form a dense, interconnected network, with some brighter, more concentrated regions. A small, distinct circular feature is visible on the left side of the image. The overall appearance is that of a highly resolved, multi-scale structure, possibly representing a star-forming region or a complex interstellar medium.

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What is interferometry?

What is interferometry ?



Interference of waves



Measurement

What is interferometry ?



Interference of waves



Measurement

Where have you seen interference of waves?

On a rainy day



Image credit: Anton/Wikimedia

On a rainy day

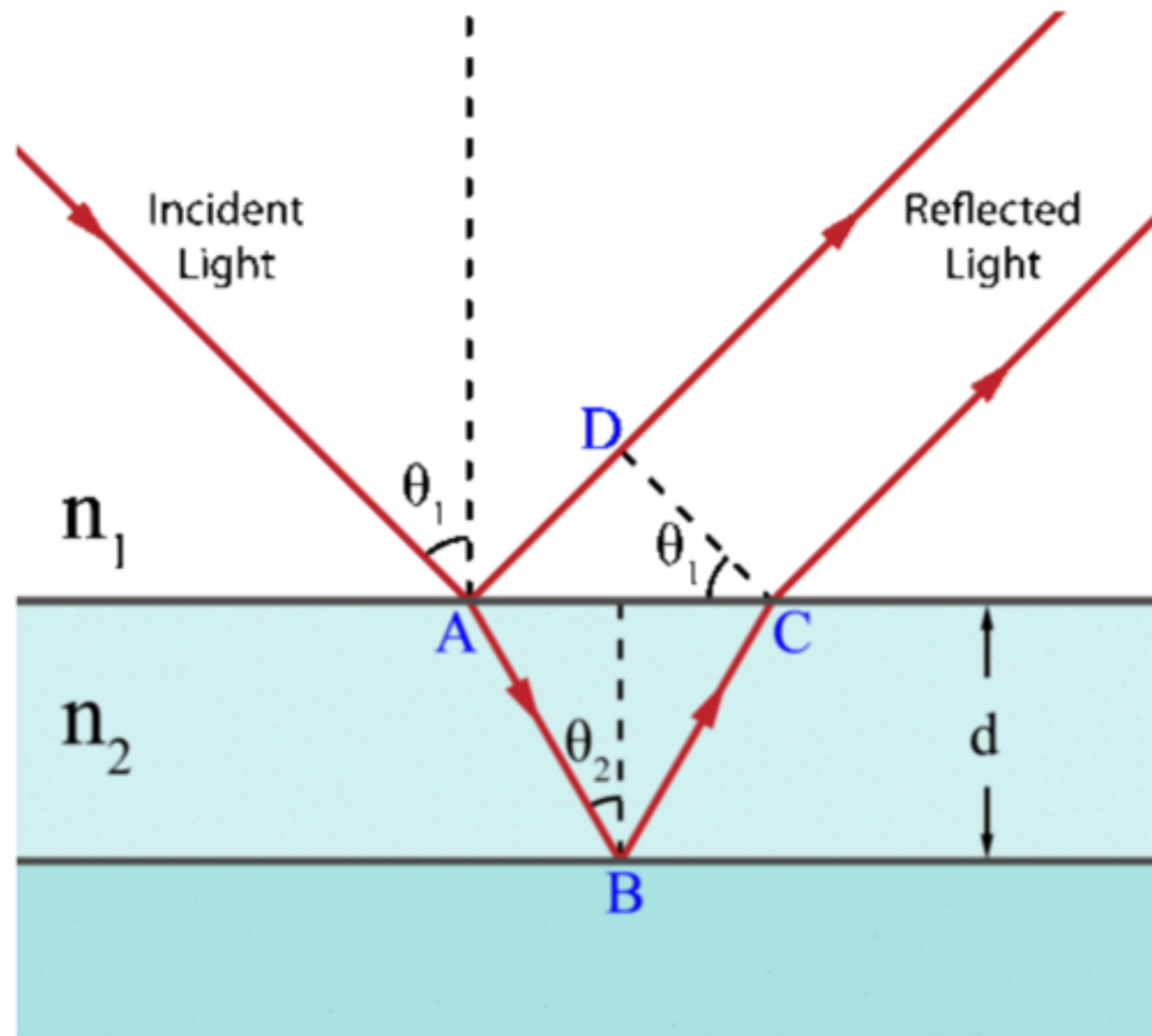


Image credit: Chanli/Wikimedia

On a rainy day

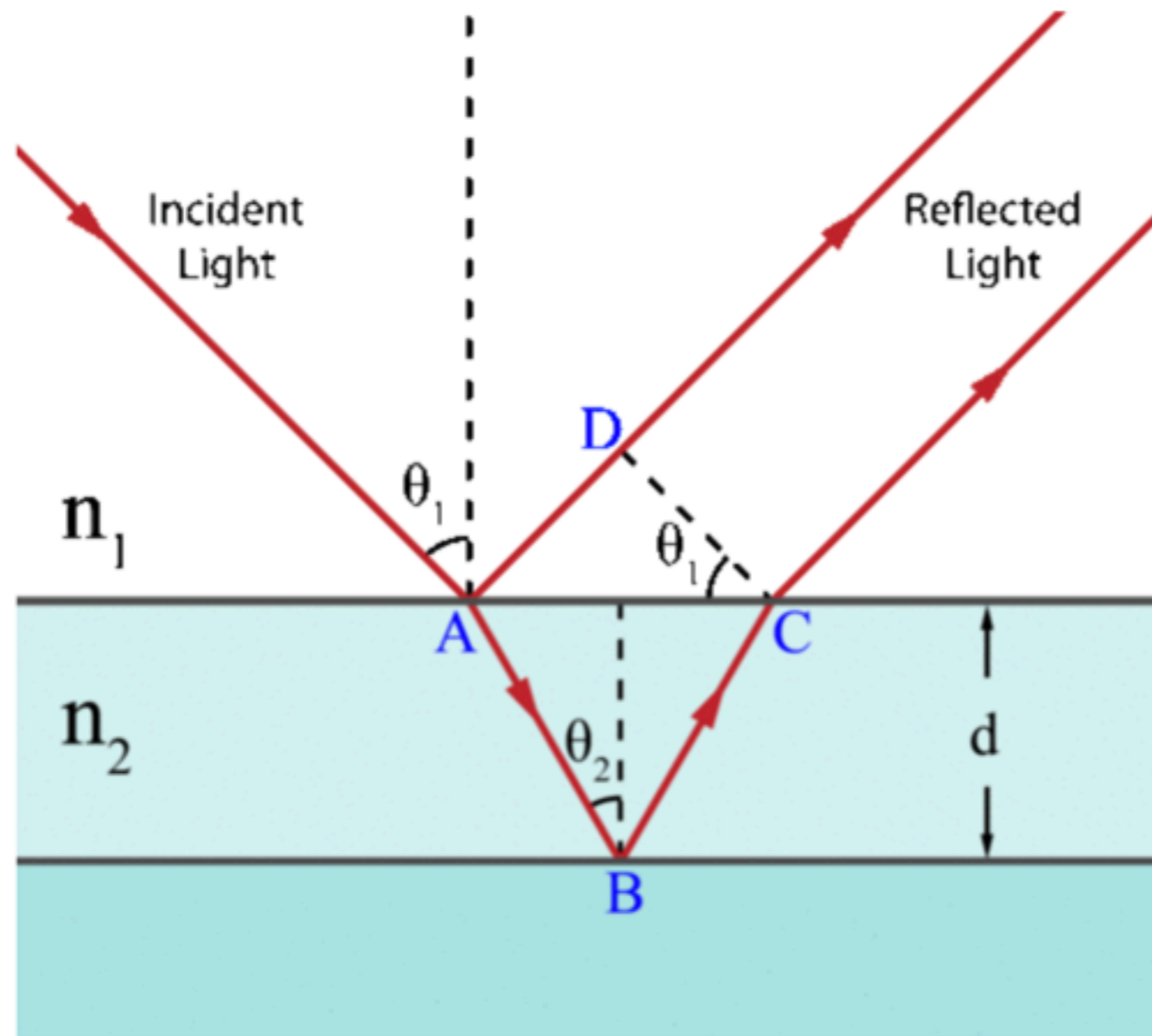


Image credit: Chanli/Wikimedia

Soap bubbles



Image credit: Alvesgaspar/Wikimedia

Butterflies, beetles, birds



Image credit: Alexcooper1/Wikimedia

This is cool

BUT

**I came to learn radio
interferometry**

This is cool

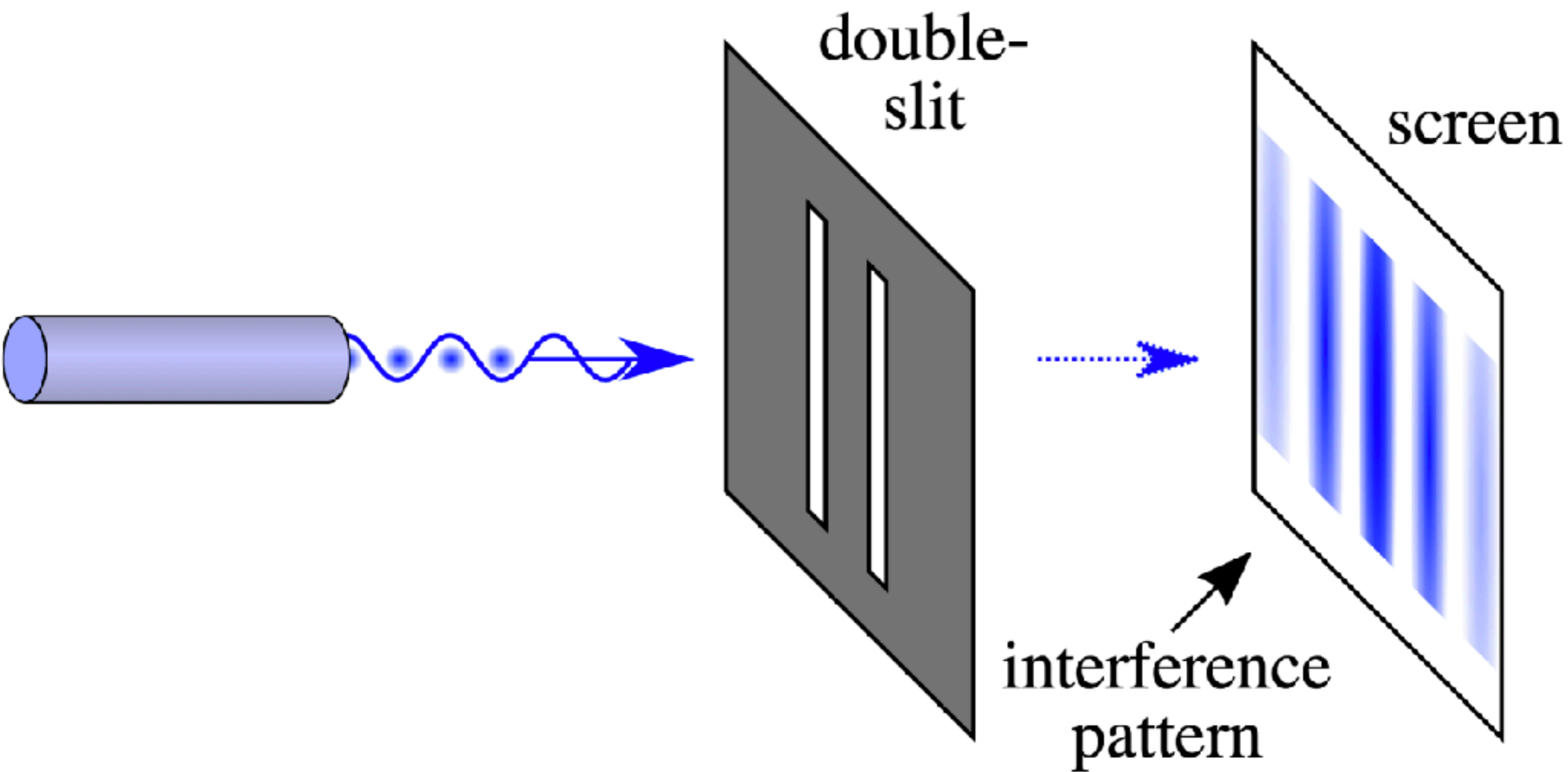
BUT

**I came to learn radio
interferometry**

I know!

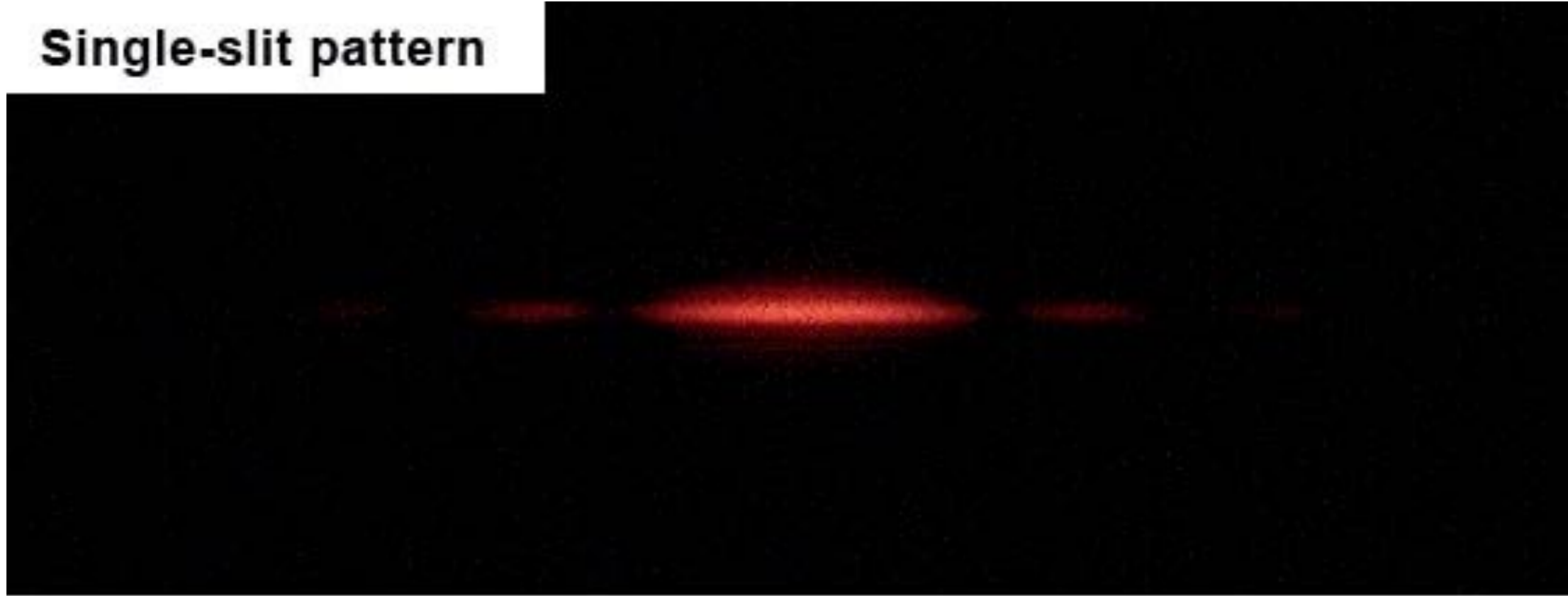
Trust in me and hang on ...

The double-slit experiment

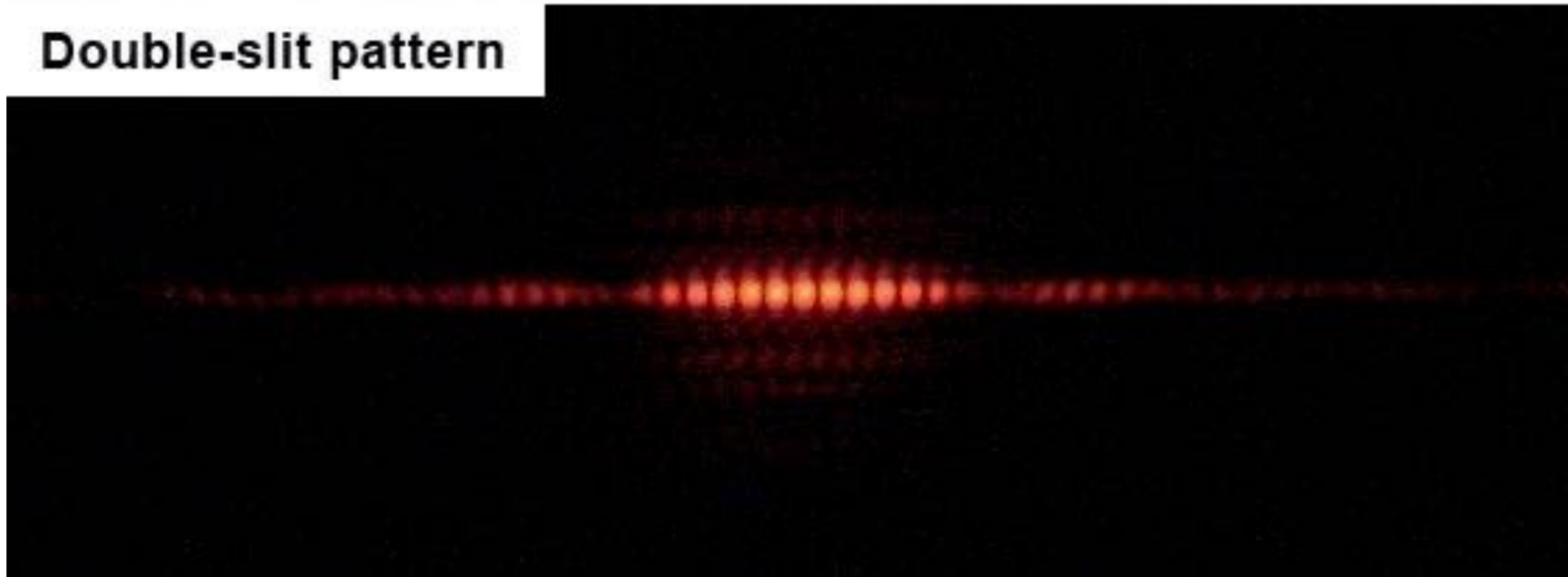


The double-slit experiment

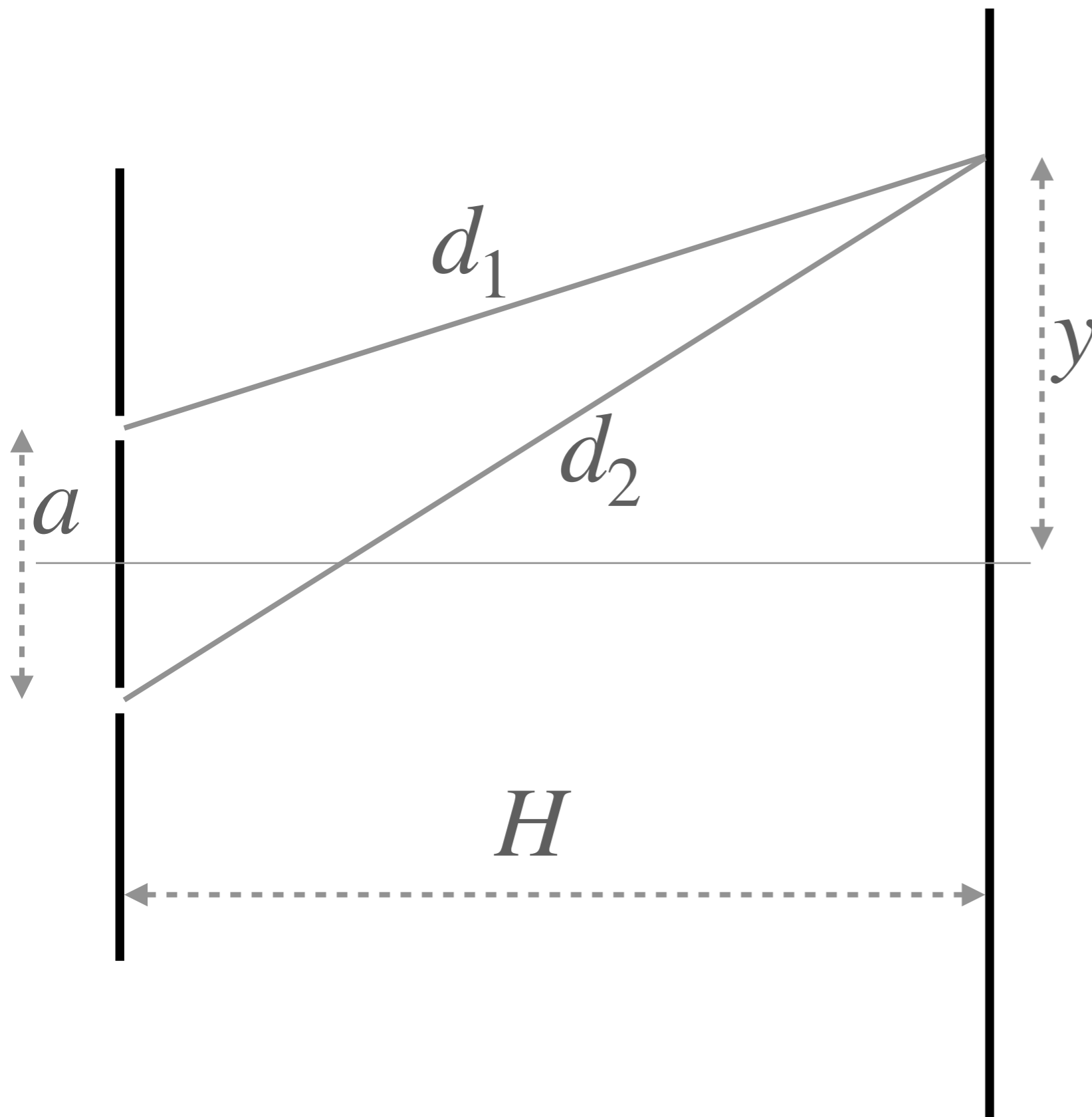
Single-slit pattern



Double-slit pattern



The double-slit experiment

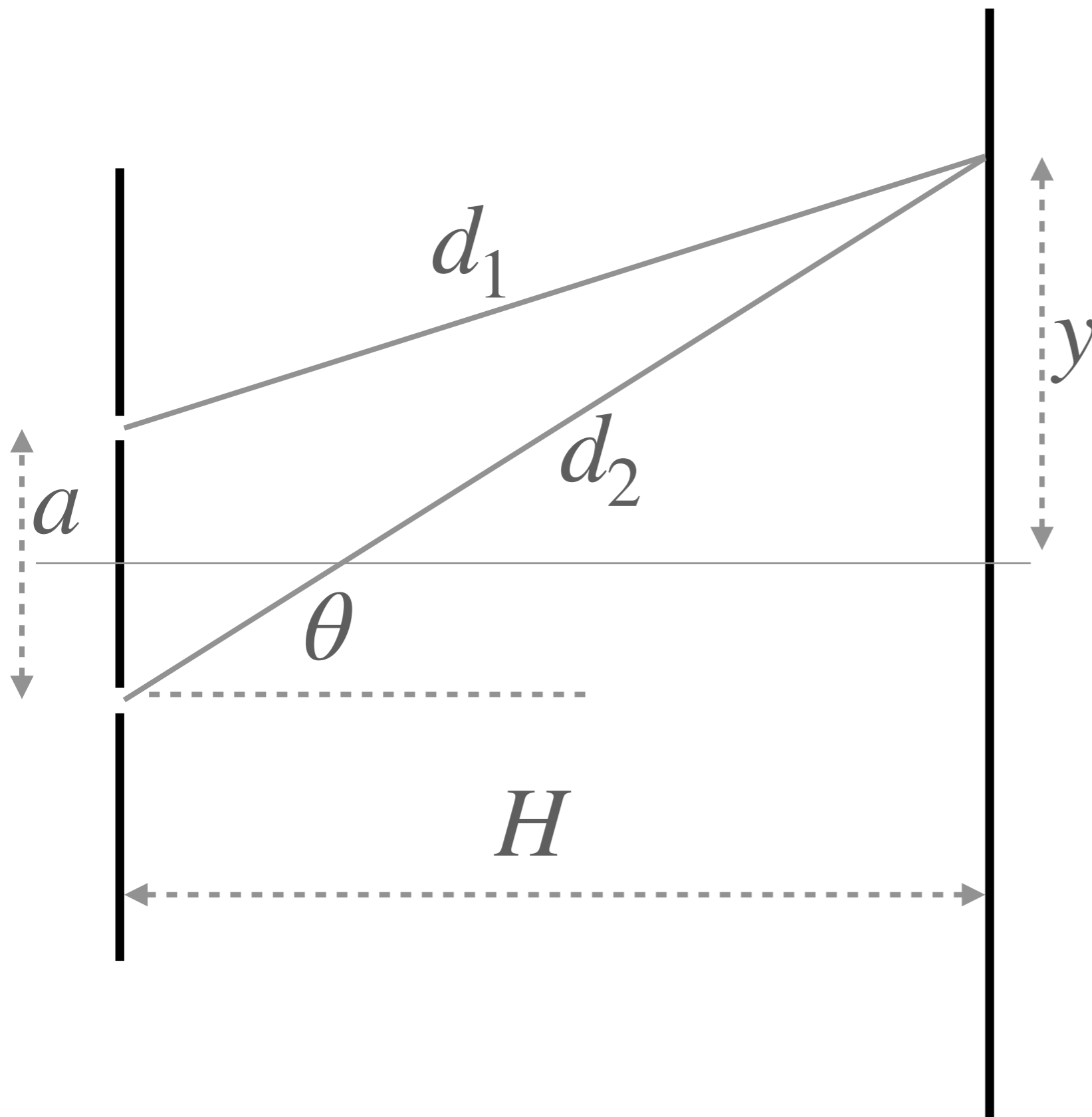


$$d_1^2 = (y - a/2)^2 + H^2$$

$$d_2^2 = (y + a/2)^2 + H^2$$

$$\Delta d(d_1 + d_2) = 2ya$$

The double-slit experiment



$$d_1^2 = (y - a/2)^2 + H^2$$

$$d_2^2 = (y + a/2)^2 + H^2$$

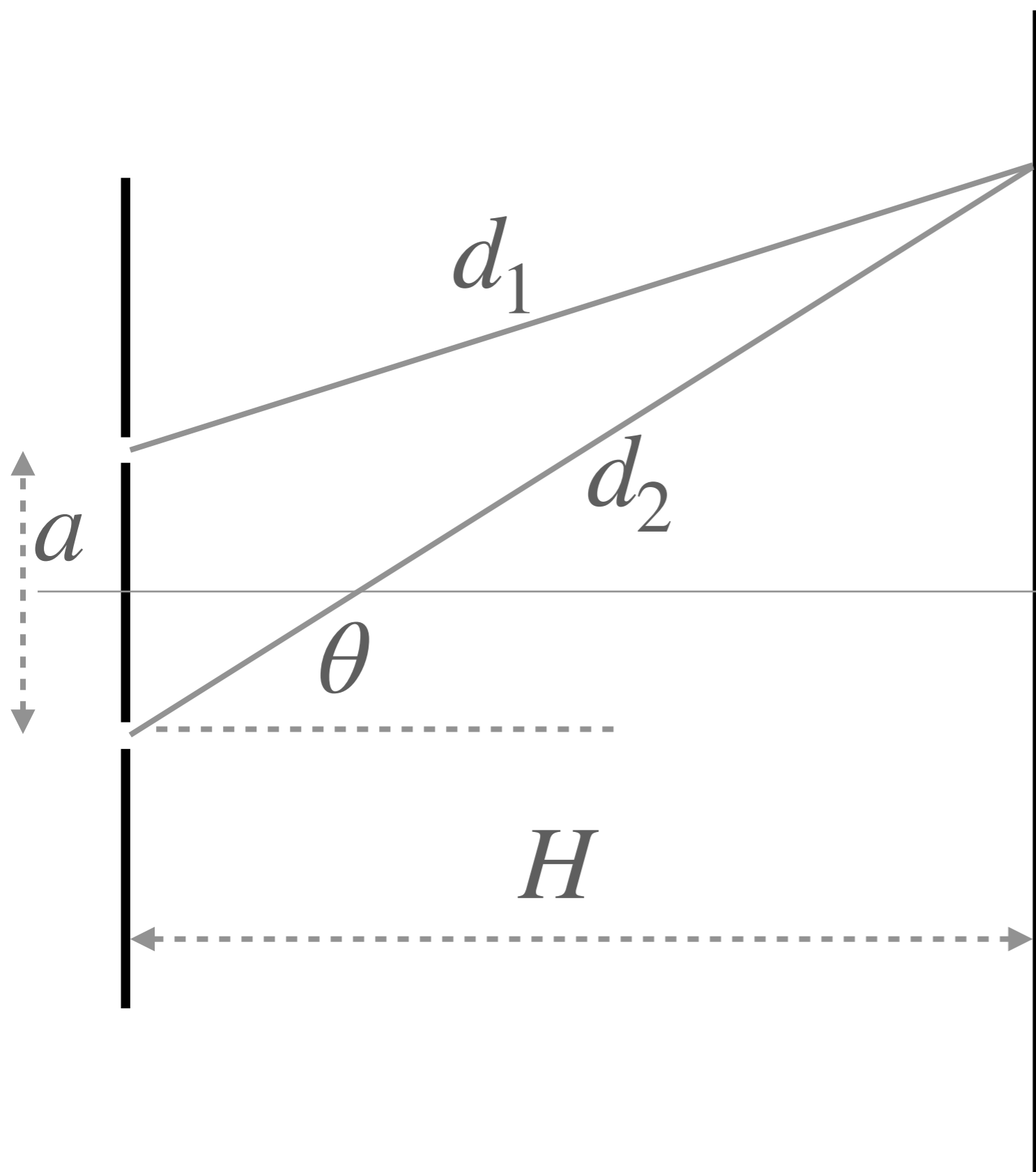
$$\Delta d(d_1 + d_2) = 2ya$$

$$d_1 + d_2 \approx 2y \sin \theta$$

(Fraunhofer)

$$\Delta d \approx a \sin \theta$$

The double-slit experiment



$$\Delta d \approx a \sin \theta$$

$$E_1 = A \exp \left(-j \frac{ka}{2} \sin \theta \right)$$

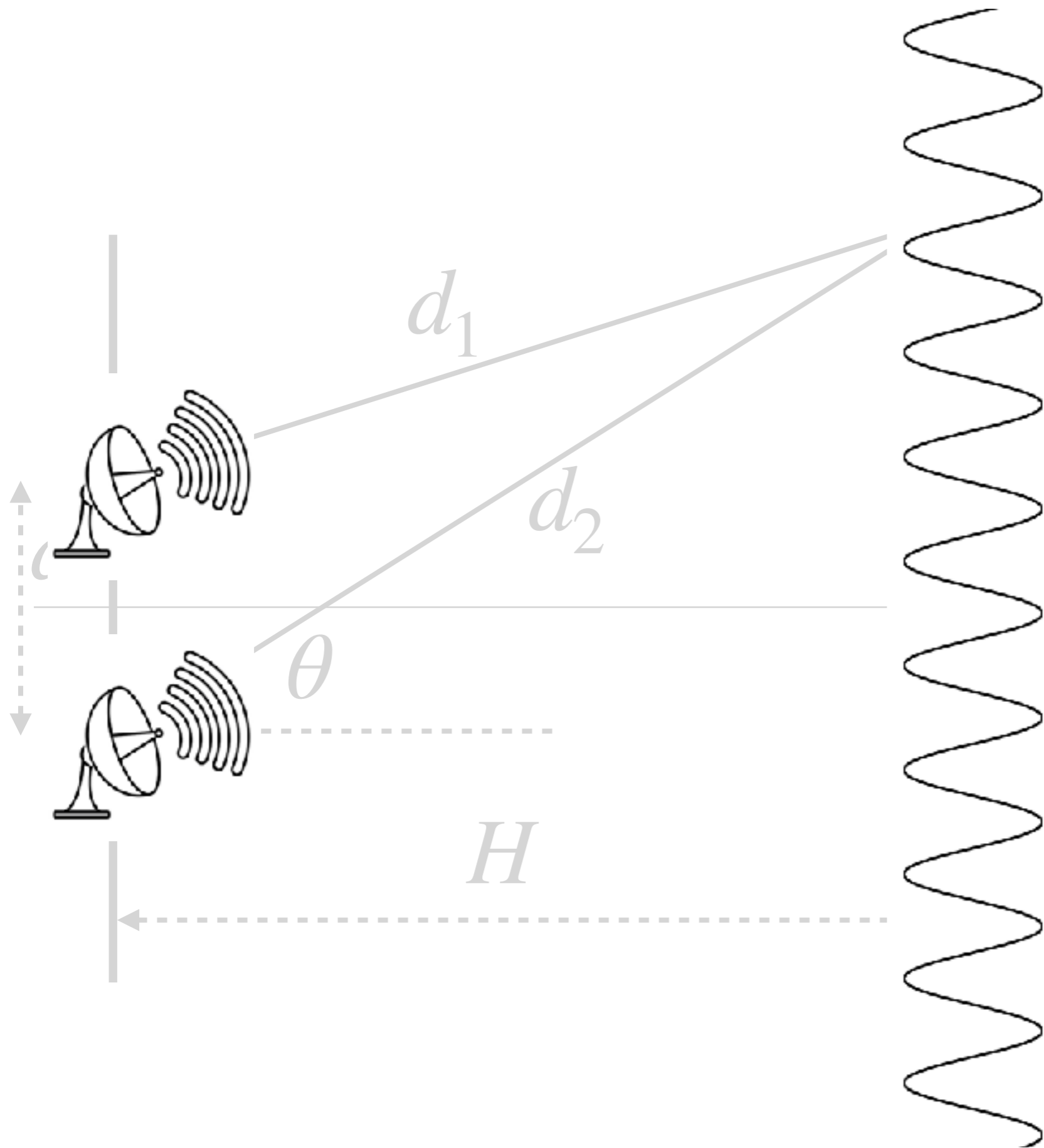
$$E_2 = A \exp \left(+j \frac{ka}{2} \sin \theta \right)$$

$$|E_1 + E_2|^2 = 4A^2 \cos^2 \left(\frac{ka}{2} \sin \theta \right)$$

$$|E_1 + E_2|^2 = 4A^2 \cos^2 \left(\frac{ka}{2} \sin \theta \right)$$

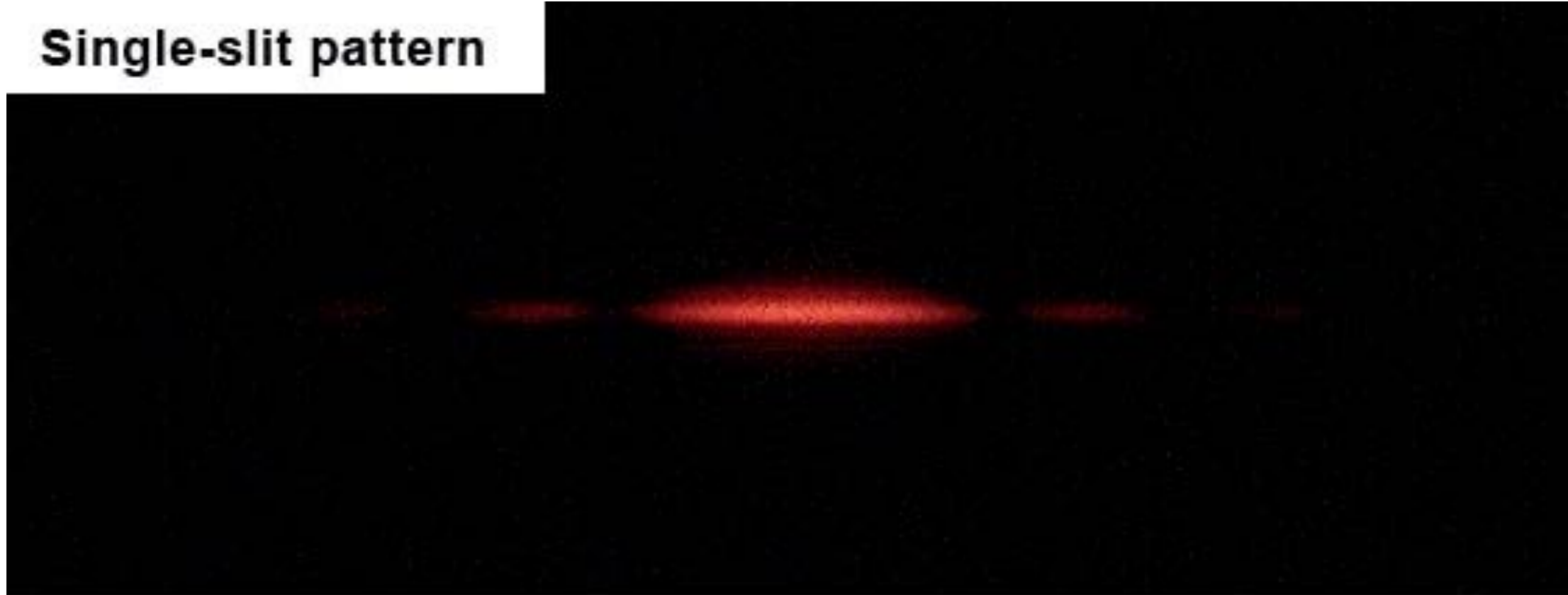
$$E_1 E_2^* = A^2 \exp (-jka \sin \theta)$$

The double-slit experiment in reverse

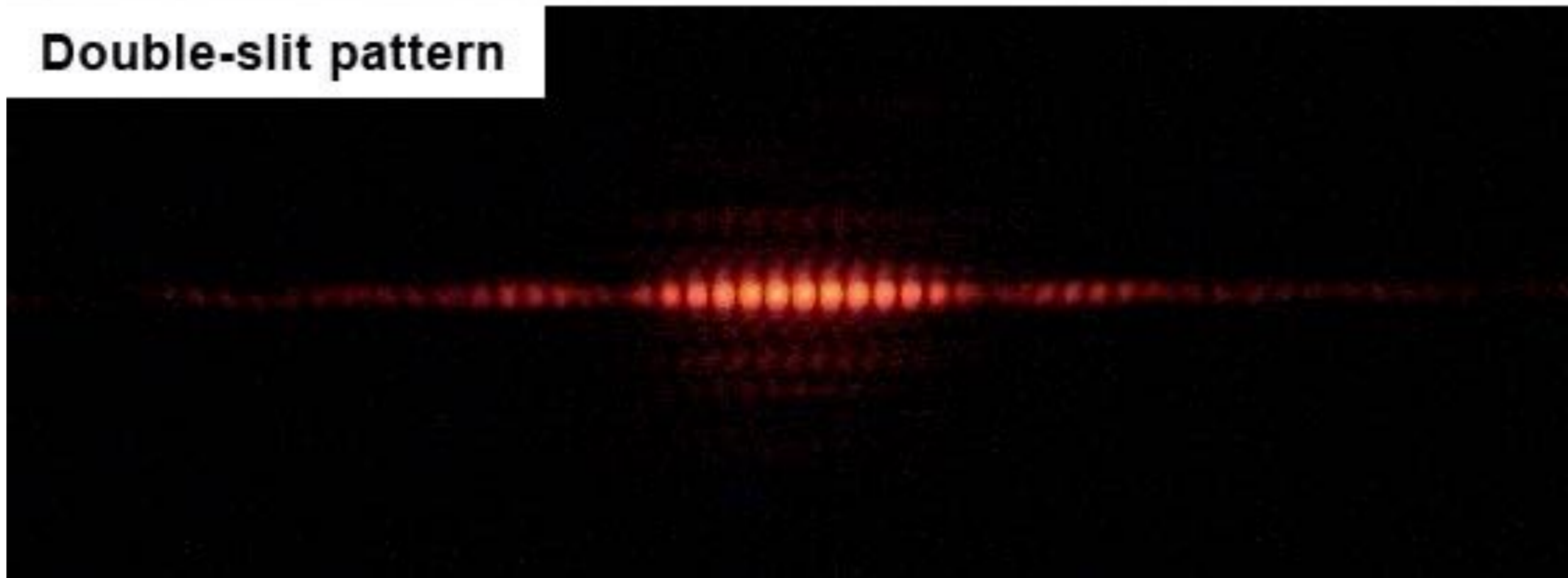


The double-slit experiment - primary beam

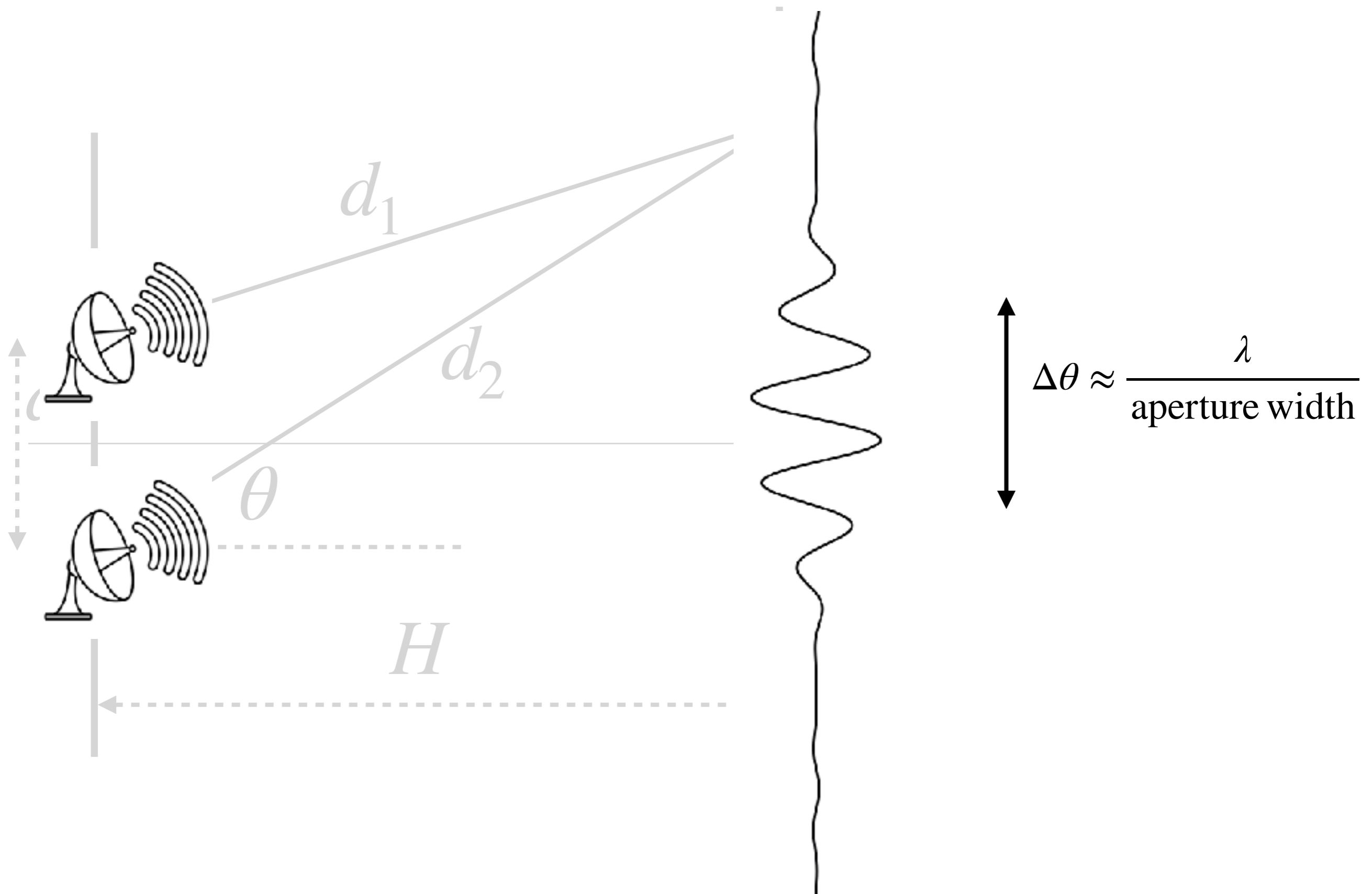
Single-slit pattern



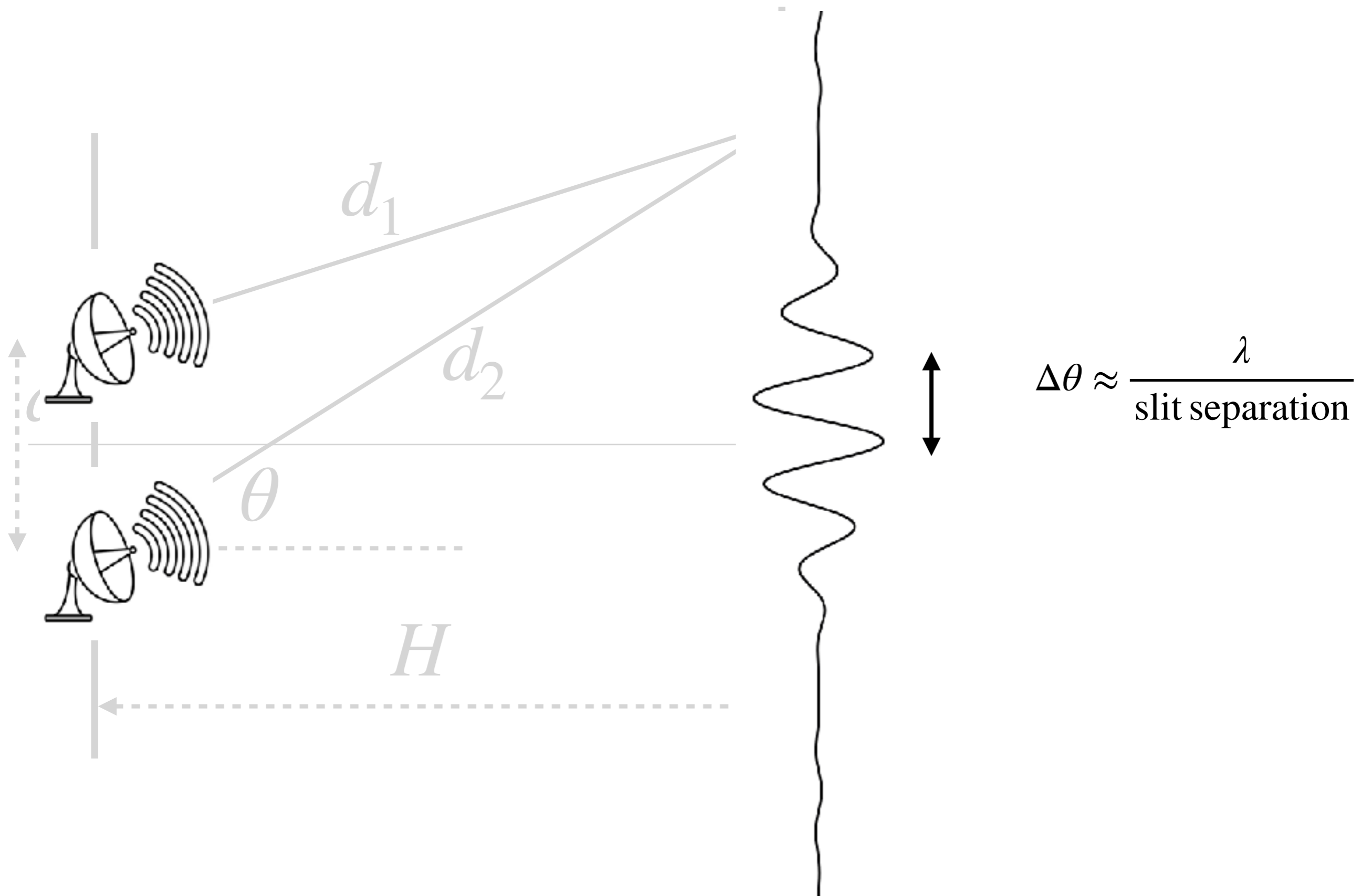
Double-slit pattern



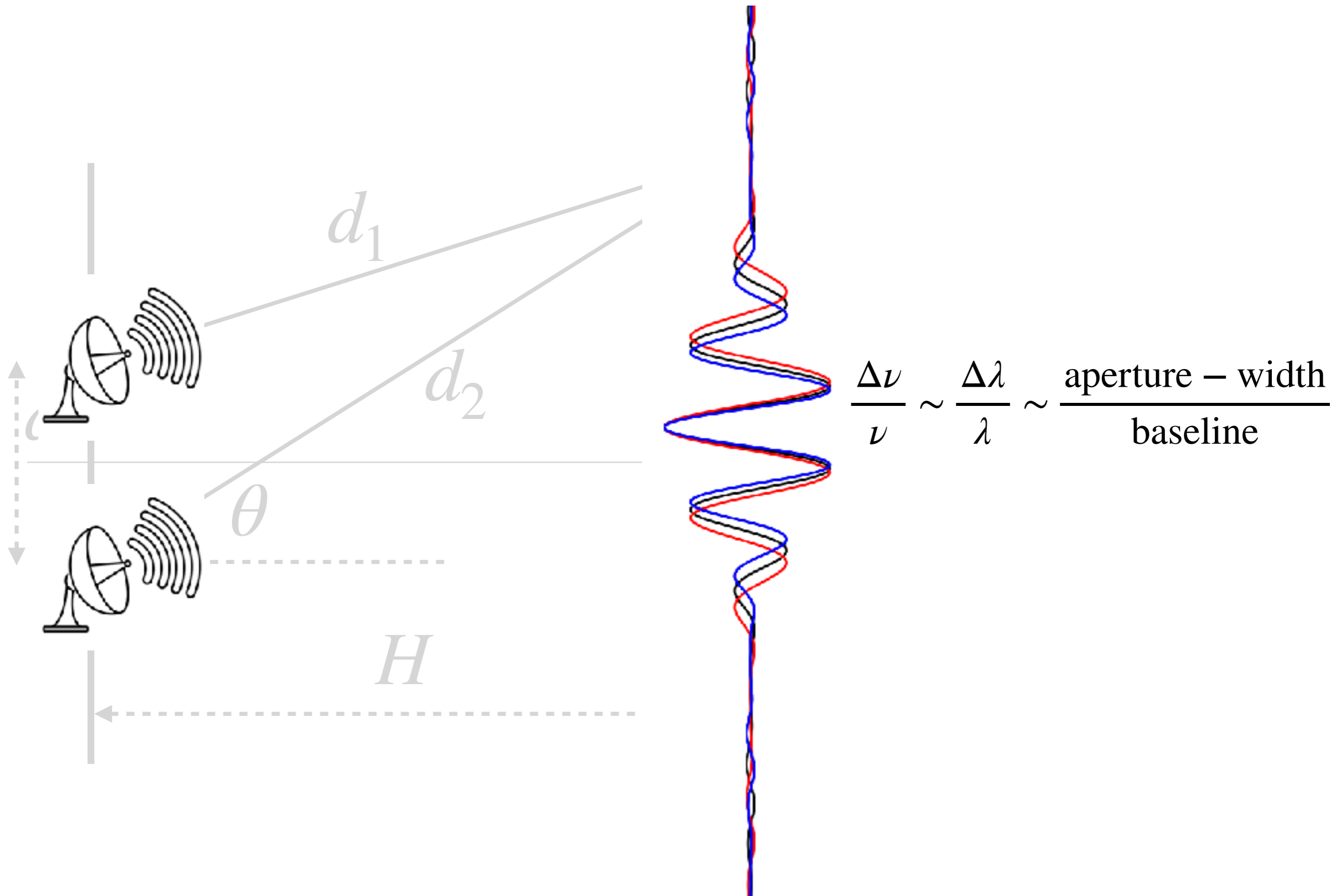
The double-slit experiment - Primary beam



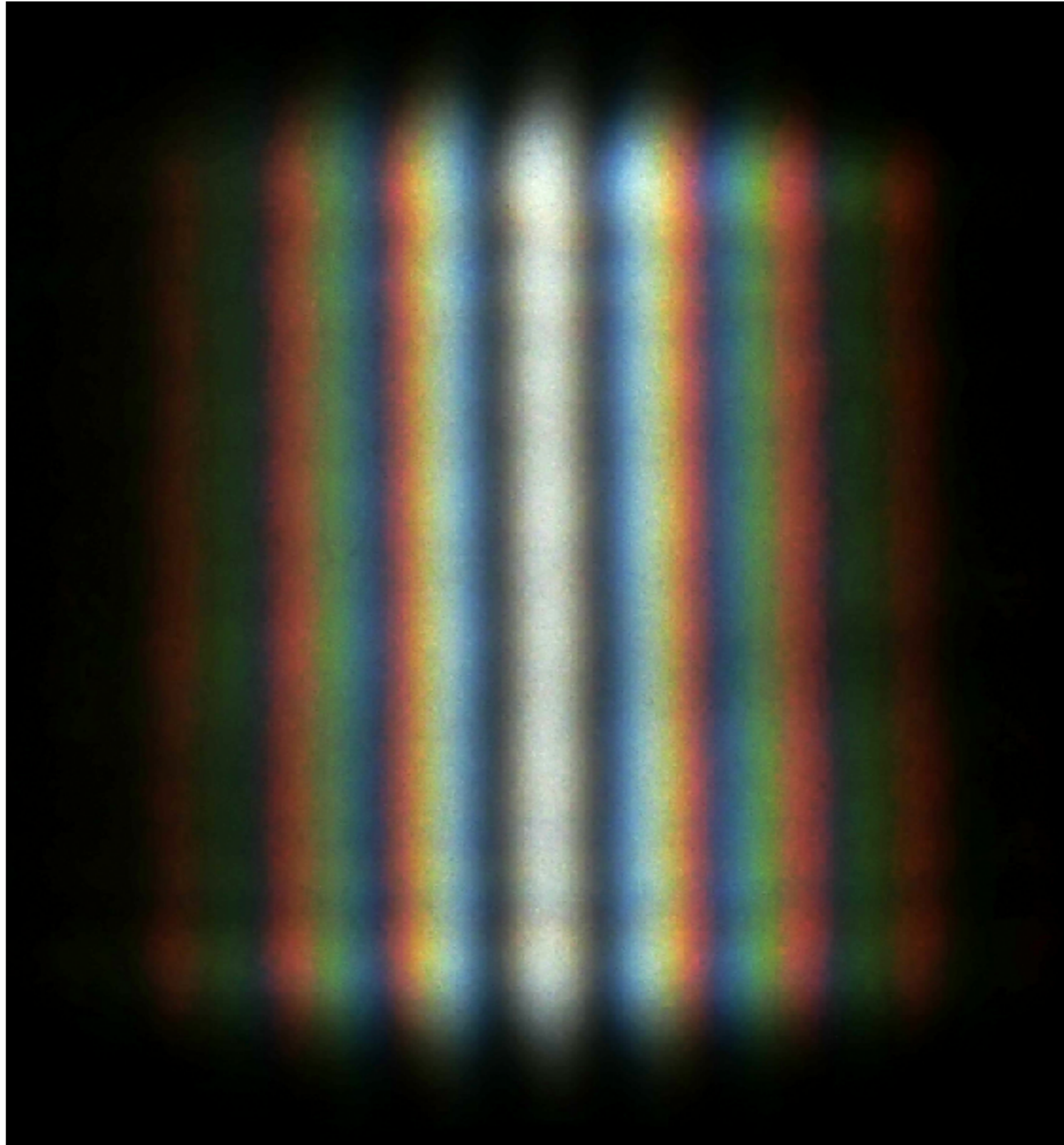
The double-slit experiment - Fringe spacing



The double-slit experiment - bandwidth smearing

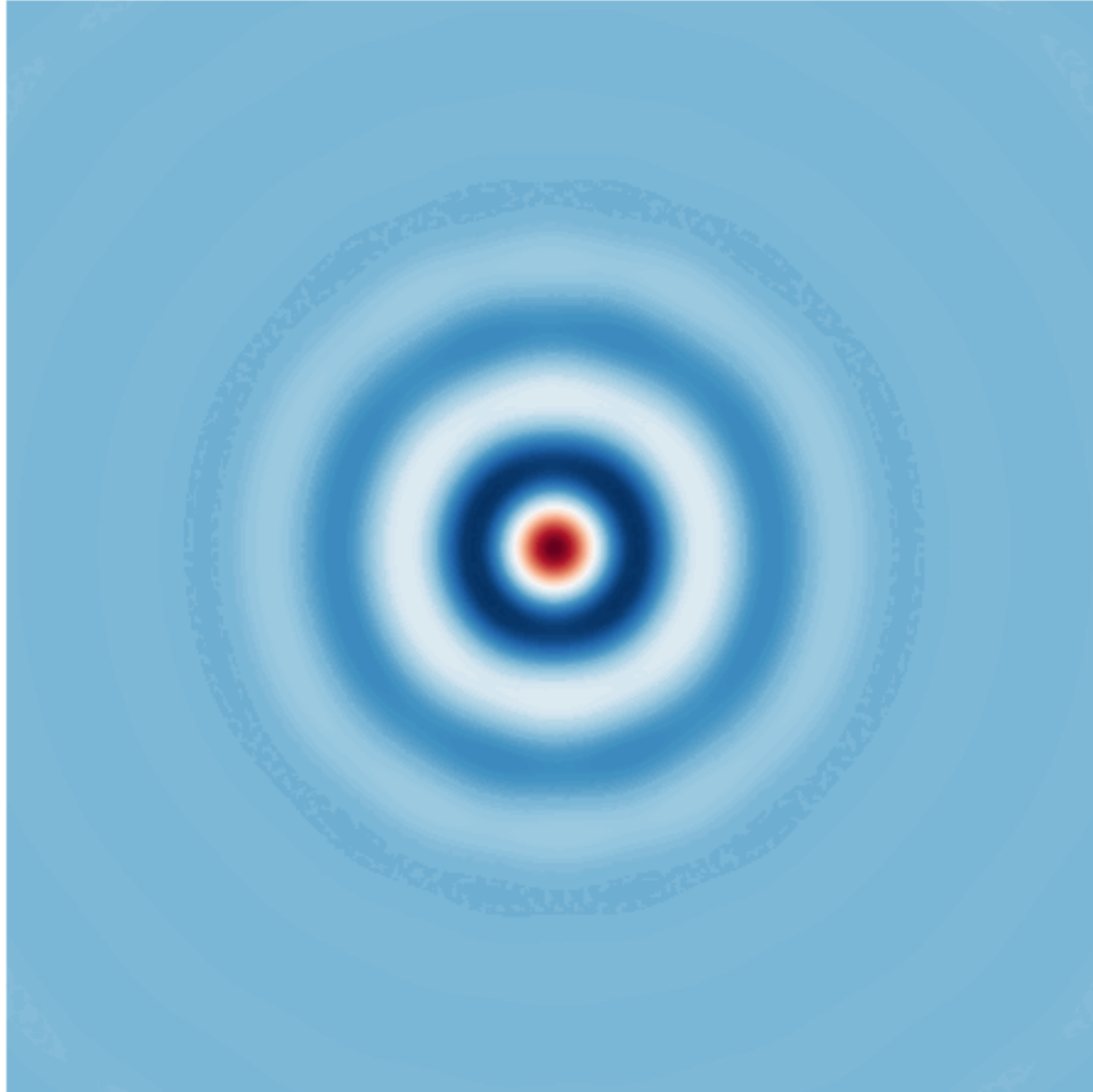


The double-slit experiment - bandwidth smearing

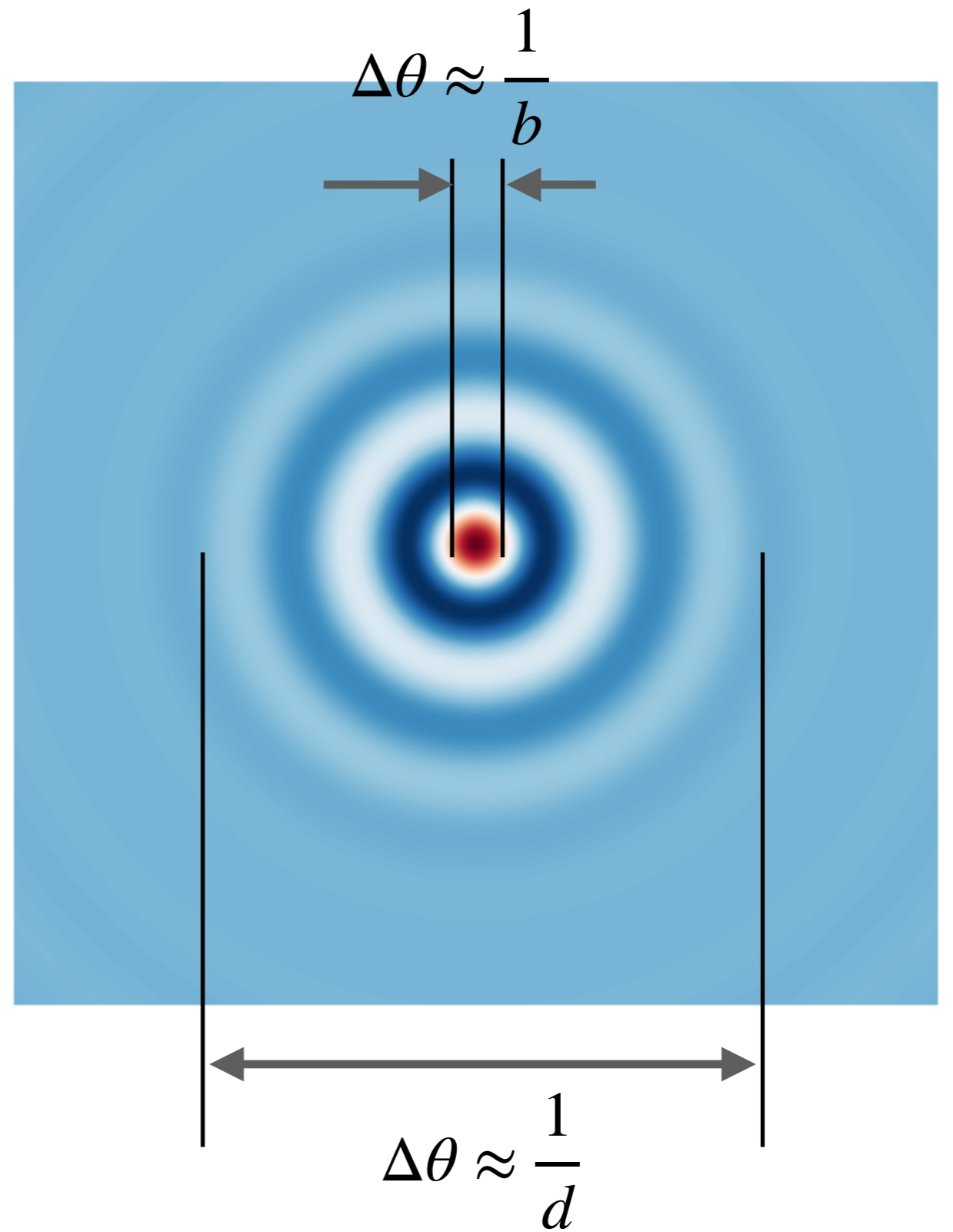
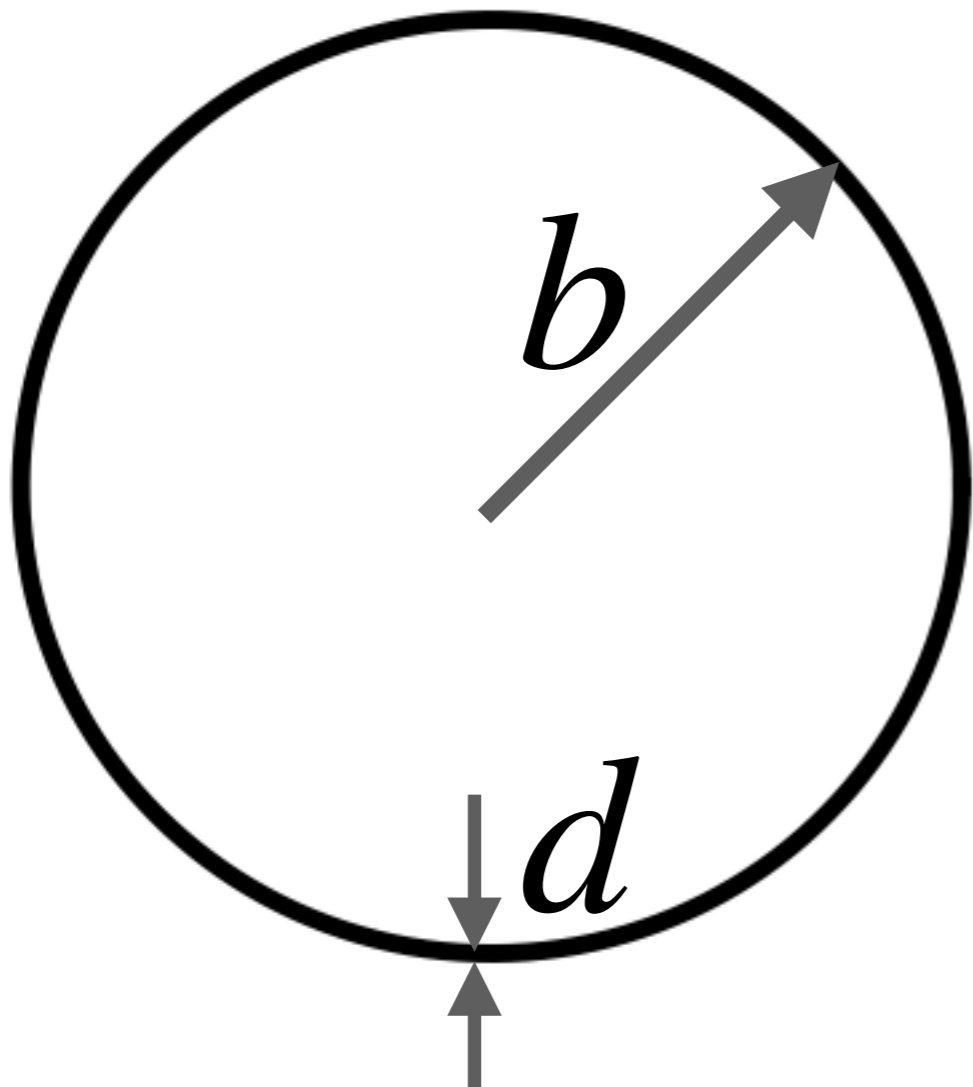


Credit: Aleksandr Berdnikov / Wikimedia

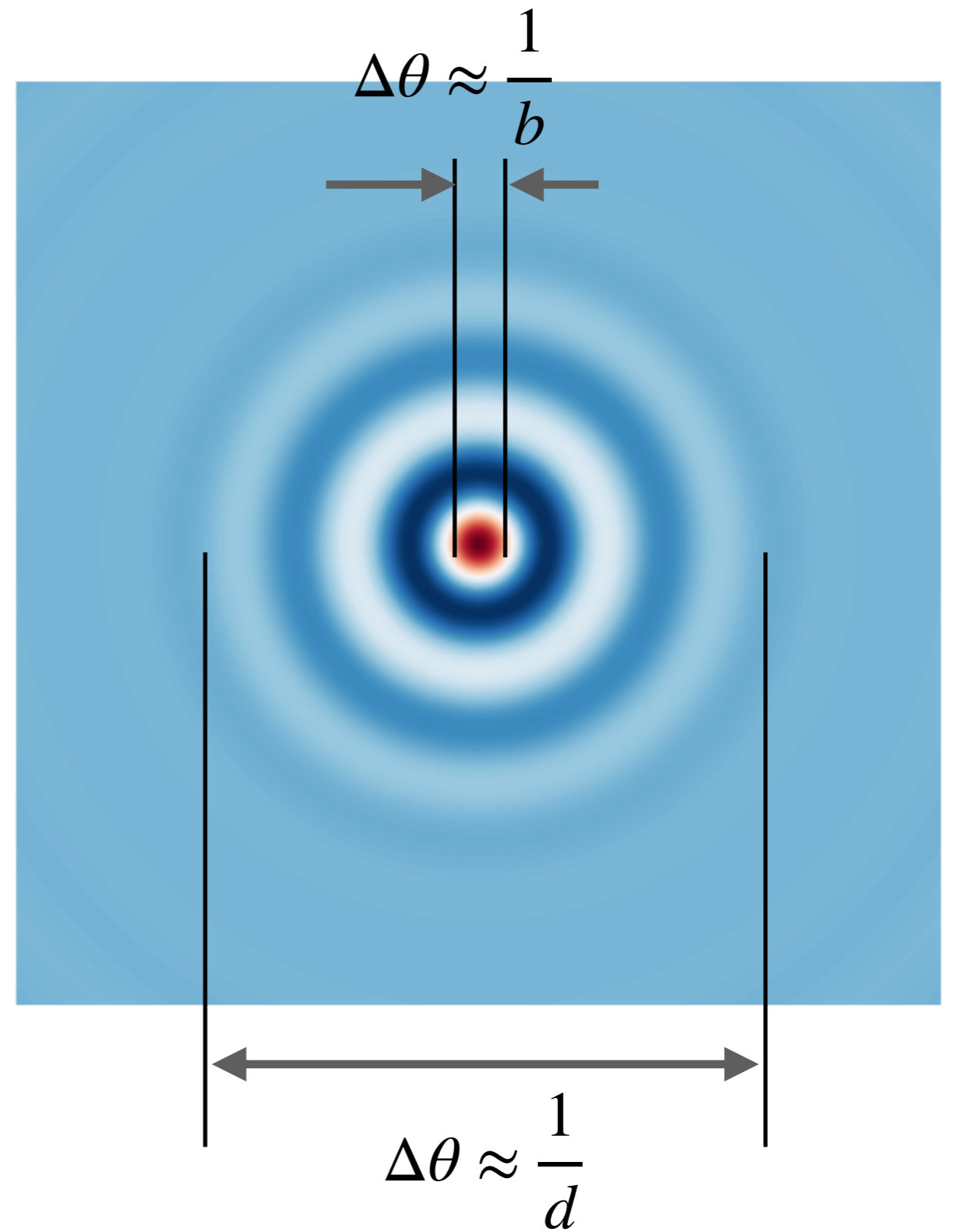
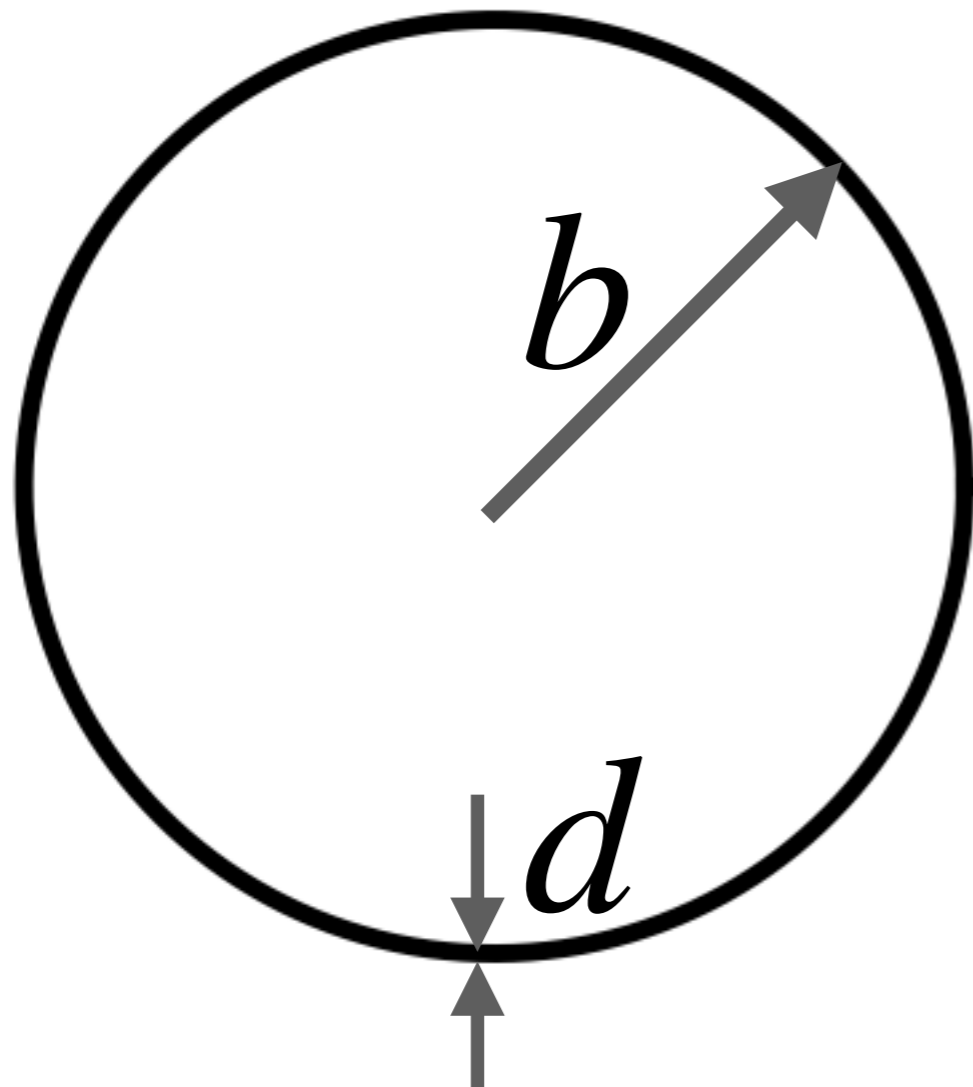
Phase coherent detection - Synthesis



Phase coherent detection - Synthesis



Phase coherent detection - Synthesis



Fourier synthesis imaging

$$I(l, m) = \int du \int dv V(u, v) \exp [-j2\pi(ul + vm)]$$

$$V(l, m) = \int dl \int dl I(u, v) \exp [j2\pi(ul + vm)]$$

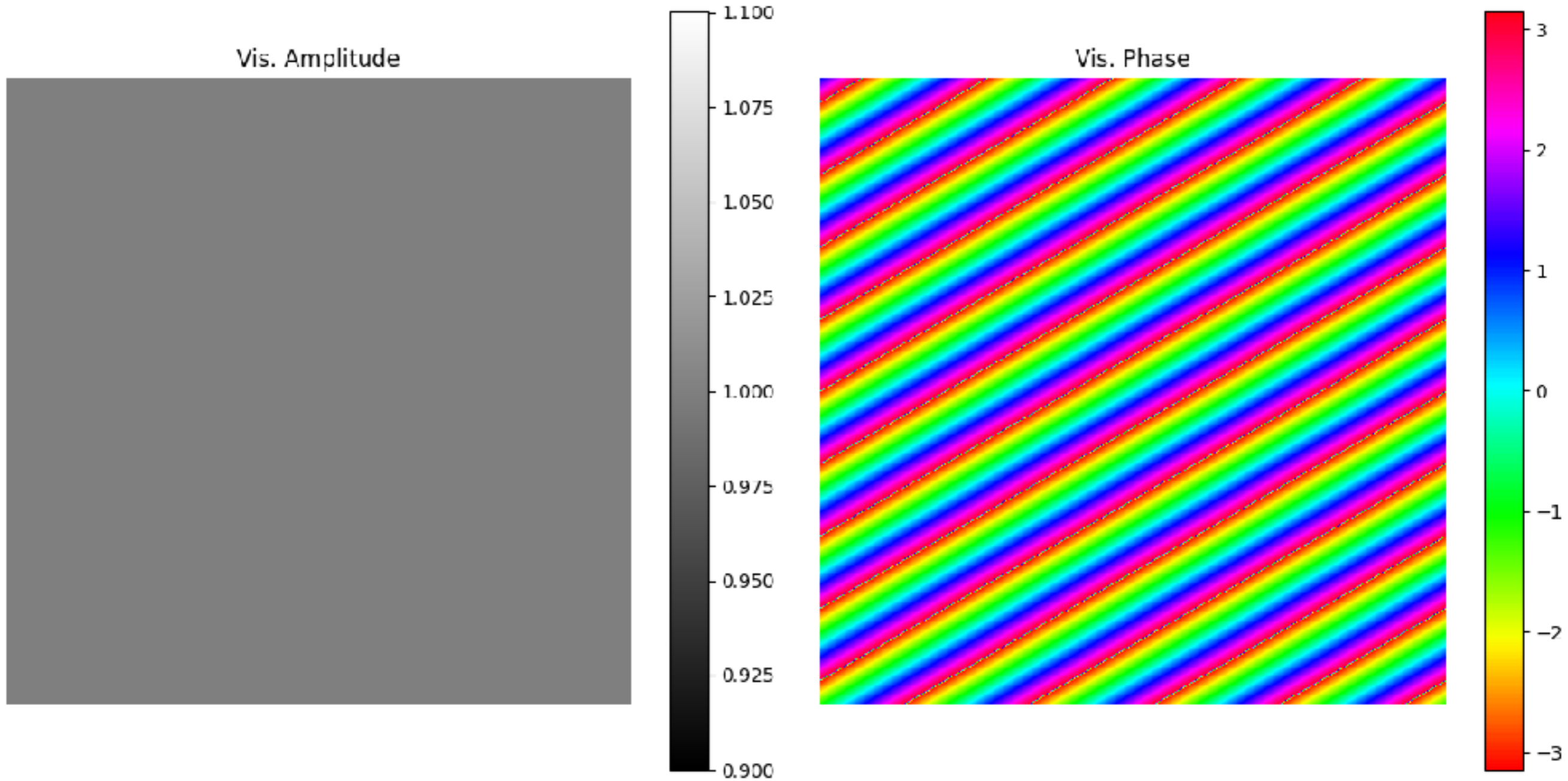
Point spread function

$$V^M(u, v) = V(u, v) \times S(u, v)$$

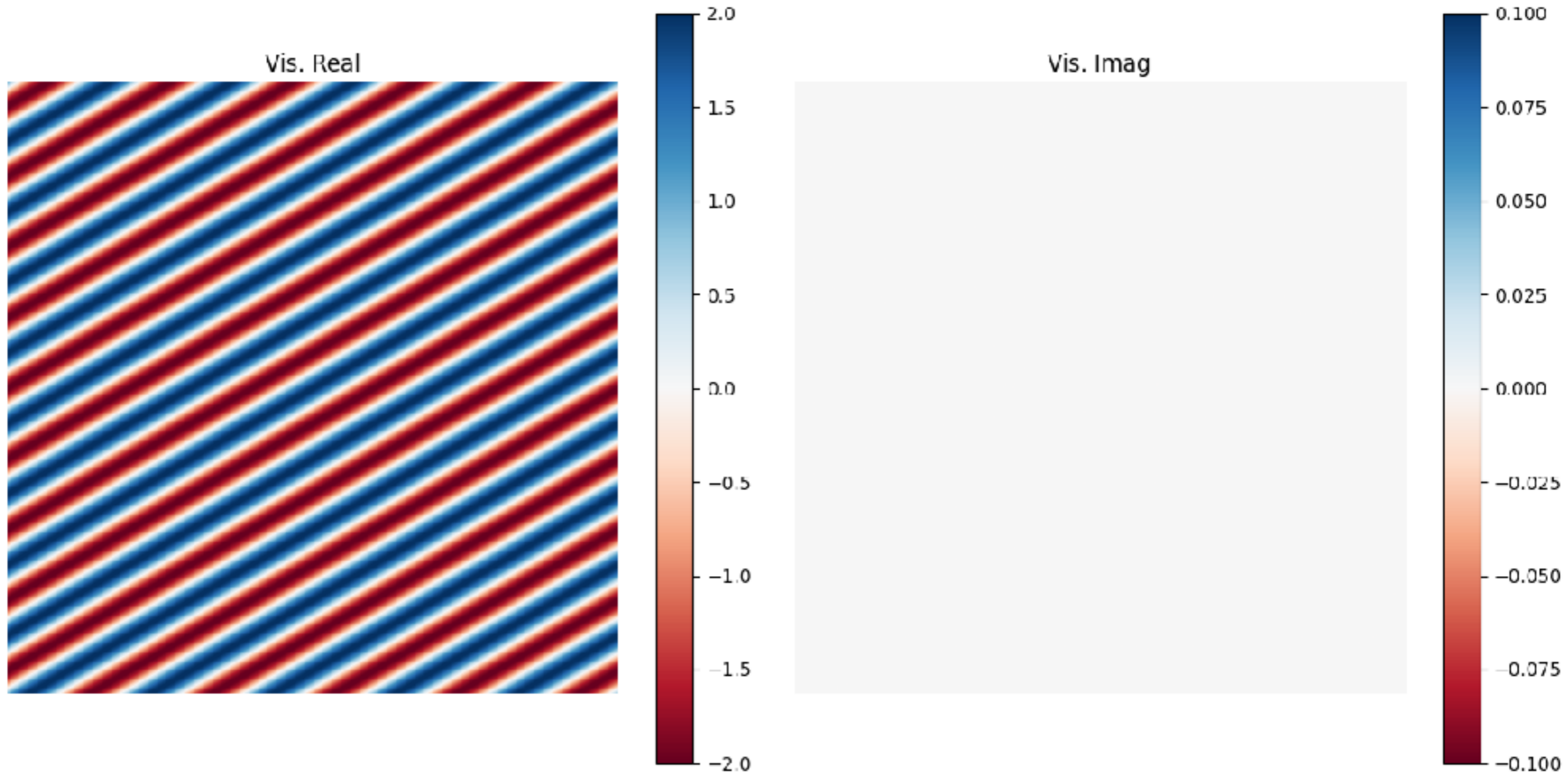
$$I^M(l, m) = I(l, m) * B(l, m)$$

$$B(l, m) = \int du \int dv S(u, v) \exp [j2\pi(ul + vm)]$$

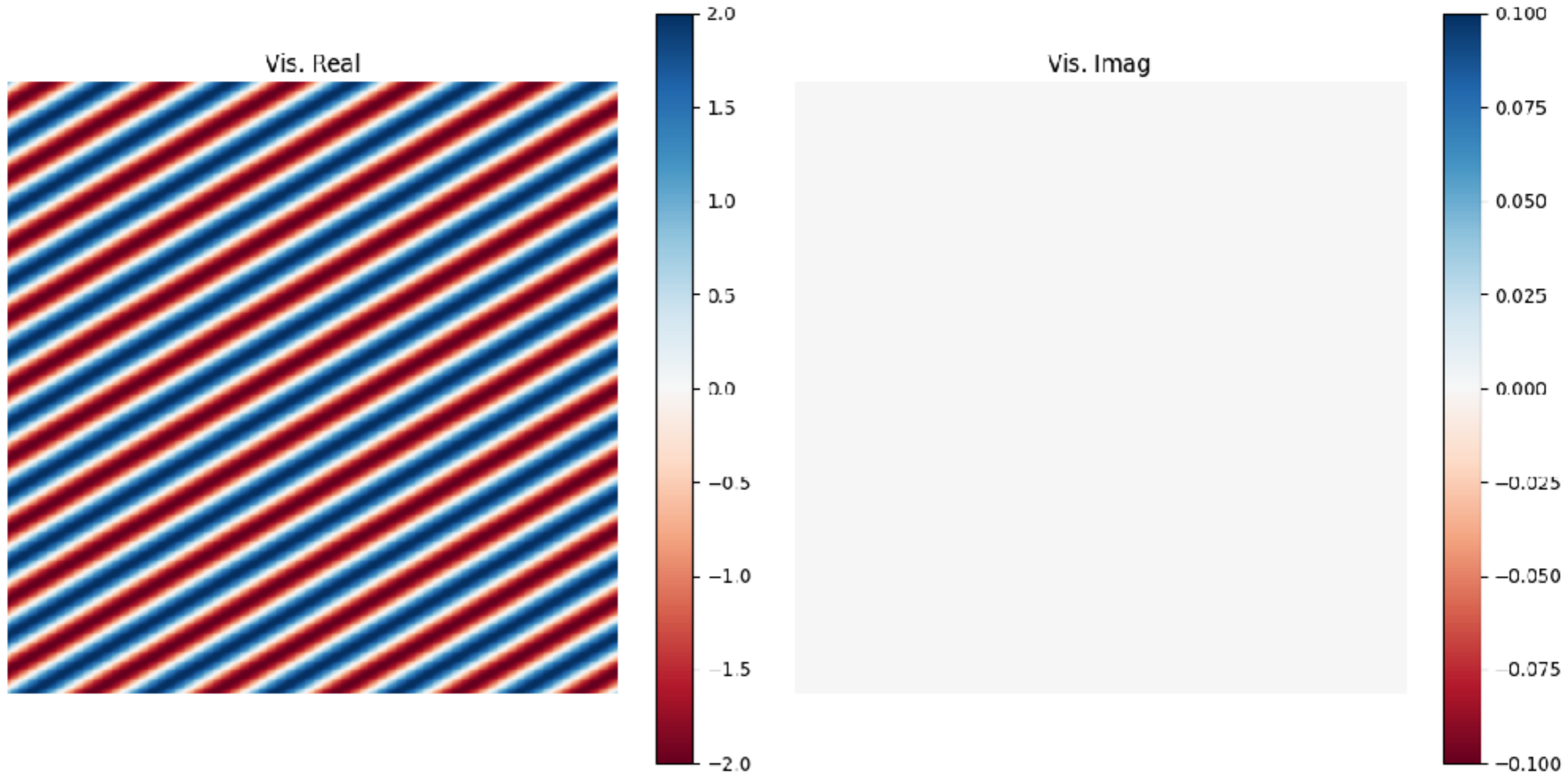
Thinking in Fourier space - what's in the sky?



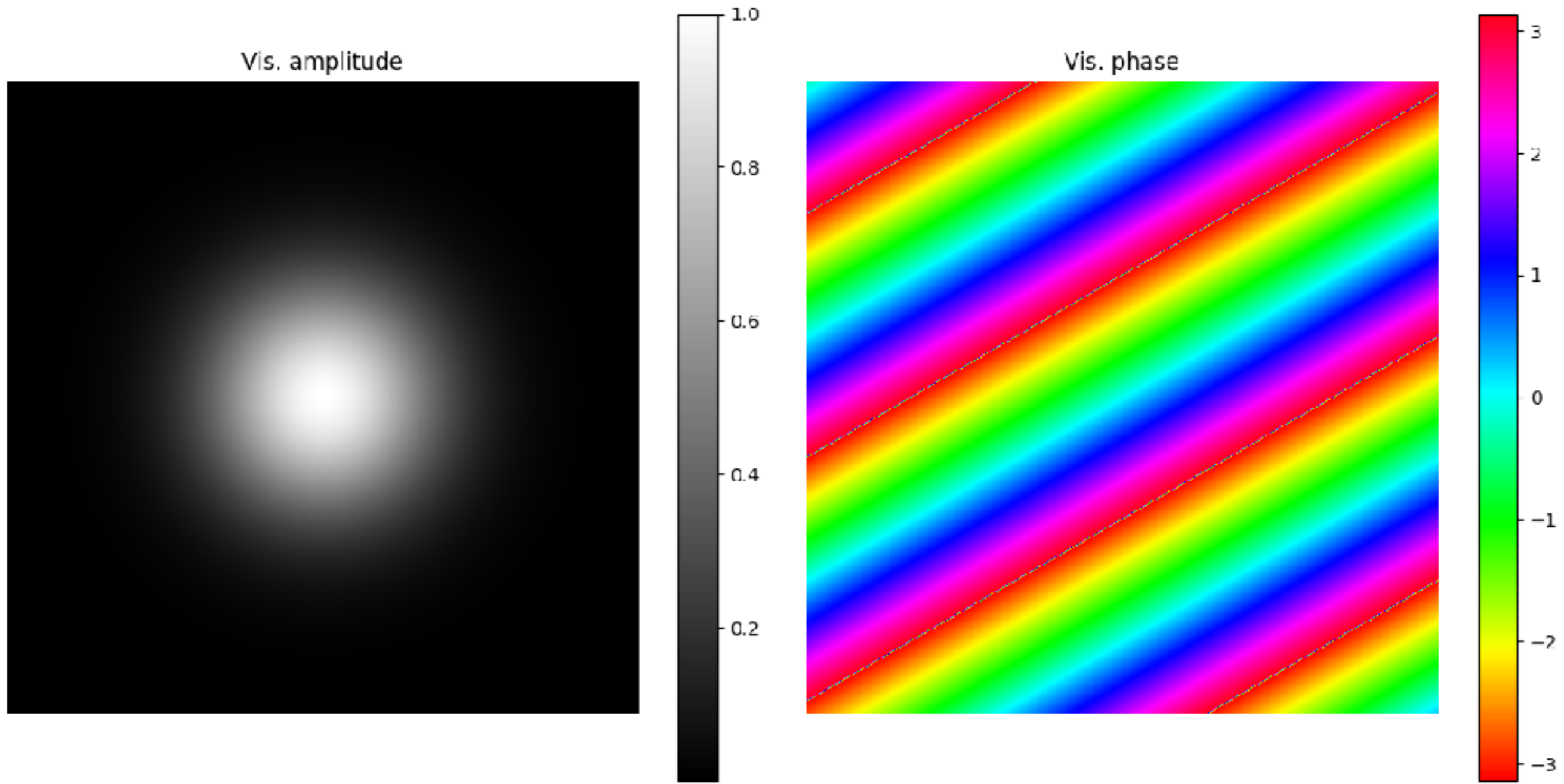
Thinking in Fourier space - what's in the sky?



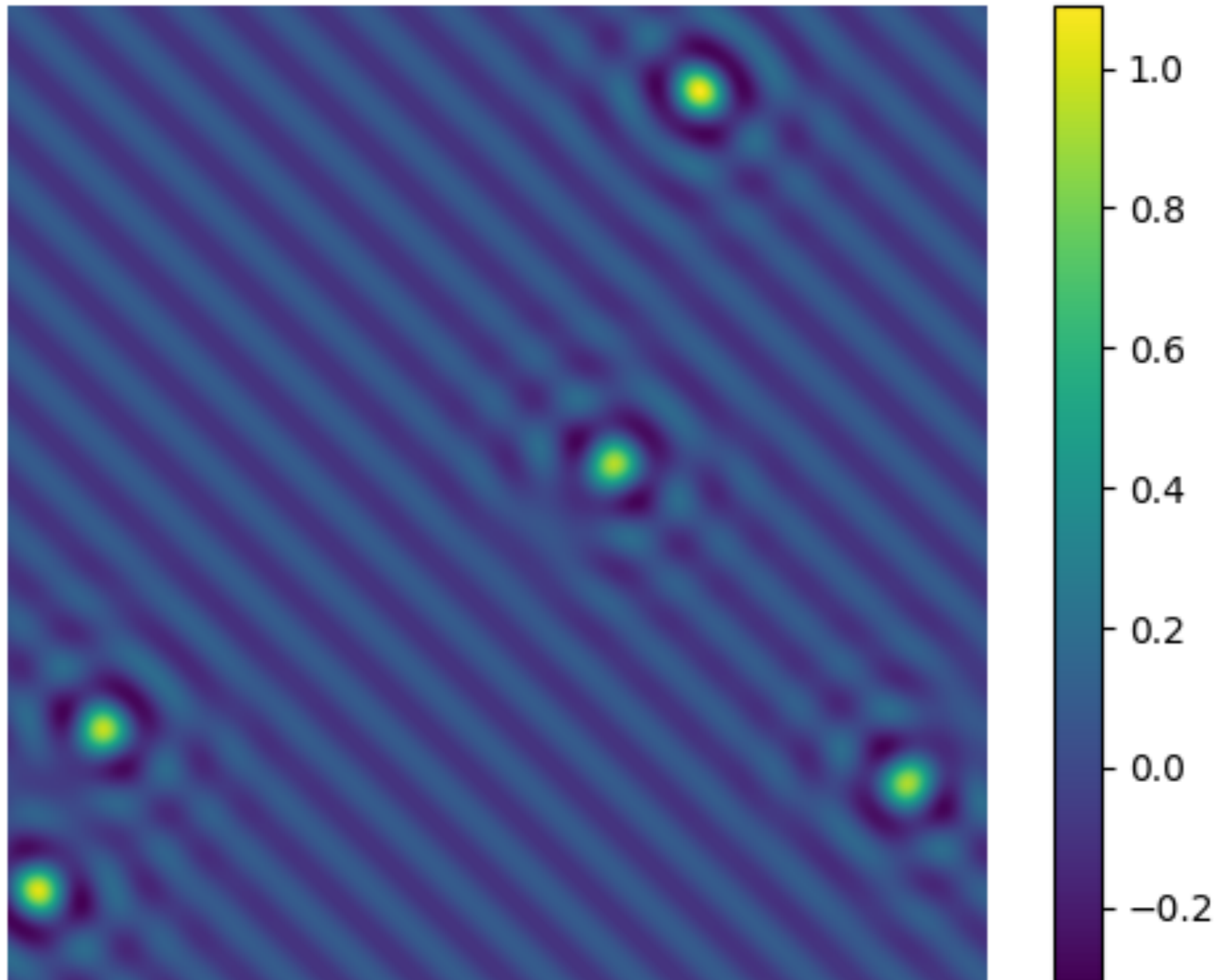
Thinking in Fourier space - what's in the sky?



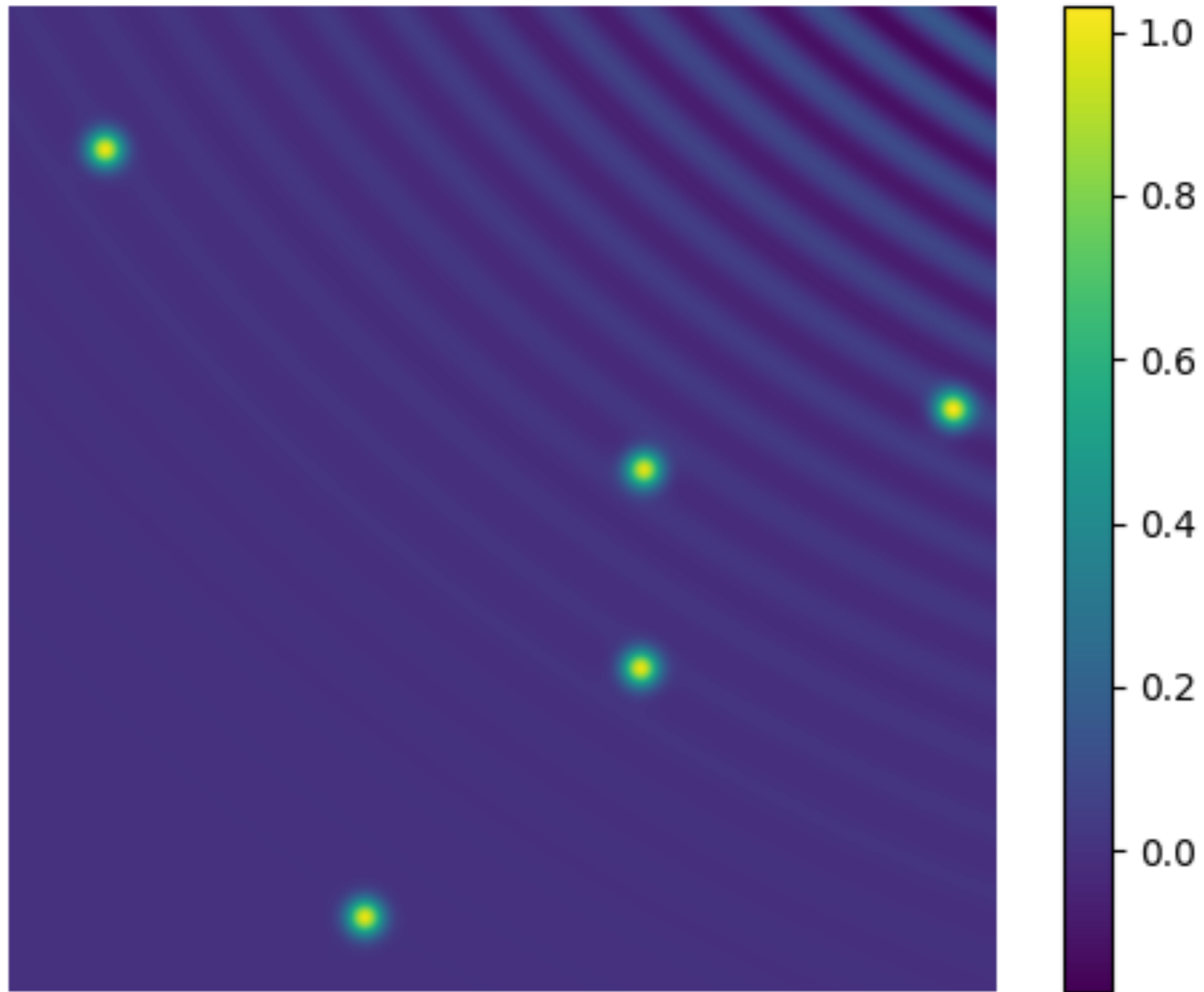
Thinking in Fourier space - what's in the sky?



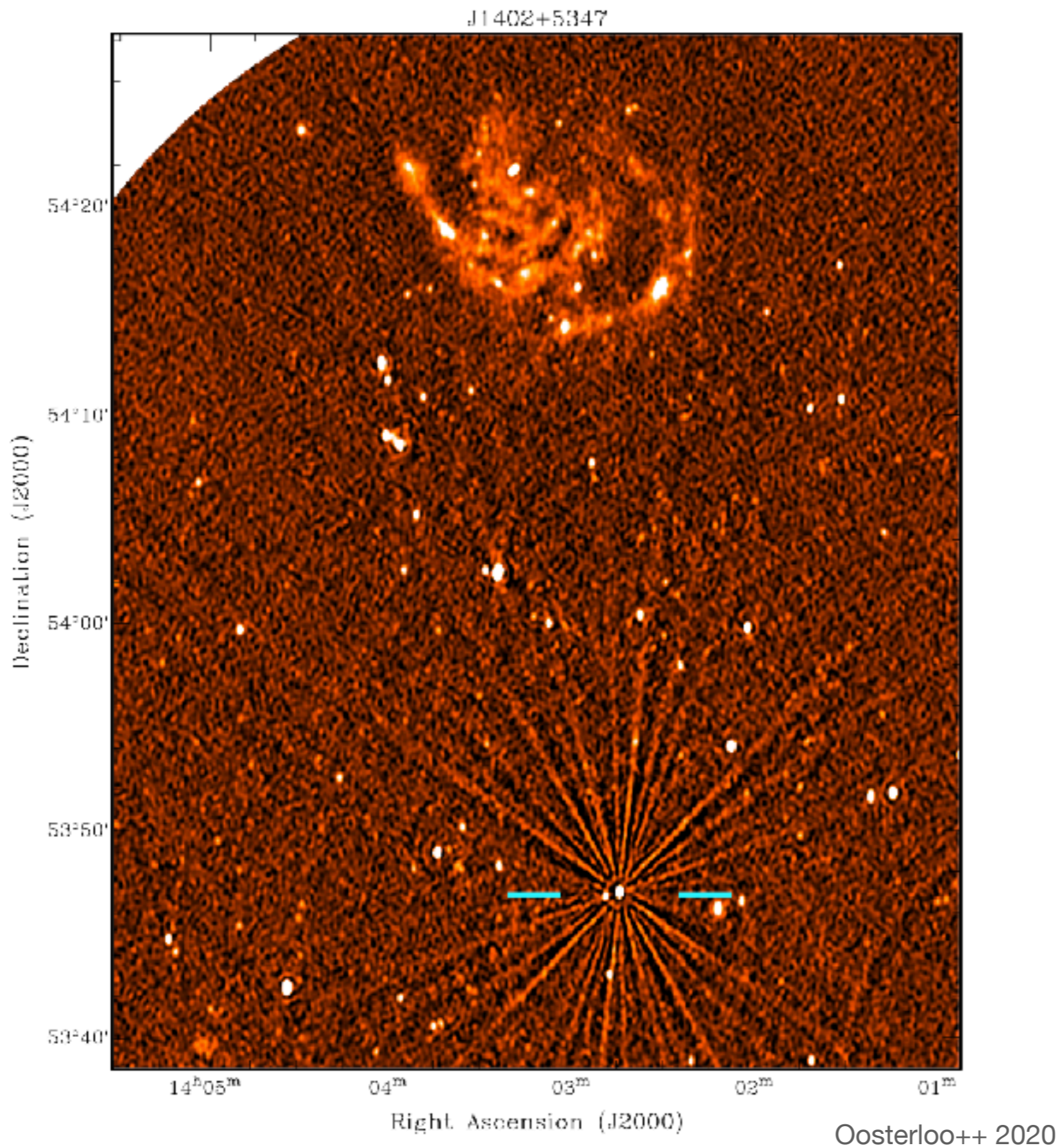
Thinking in Fourier space - what went wrong?



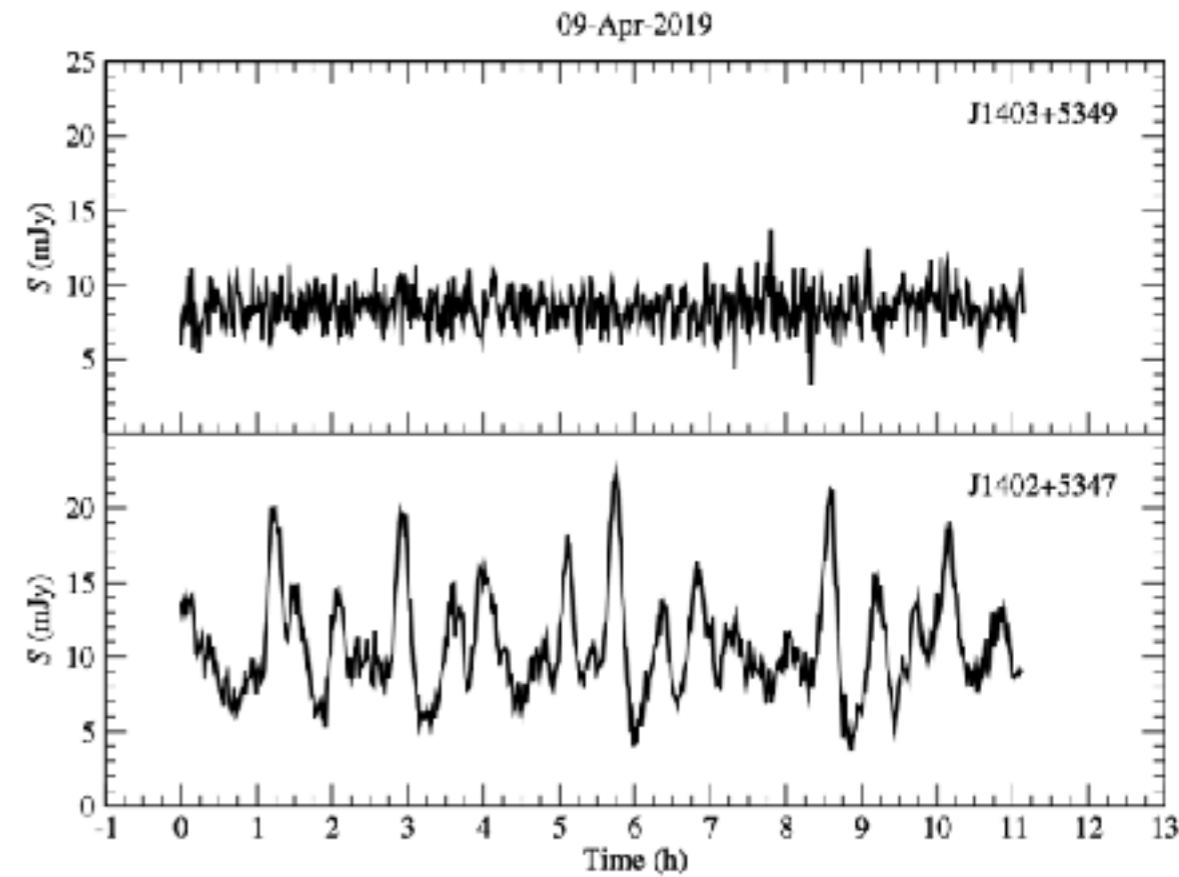
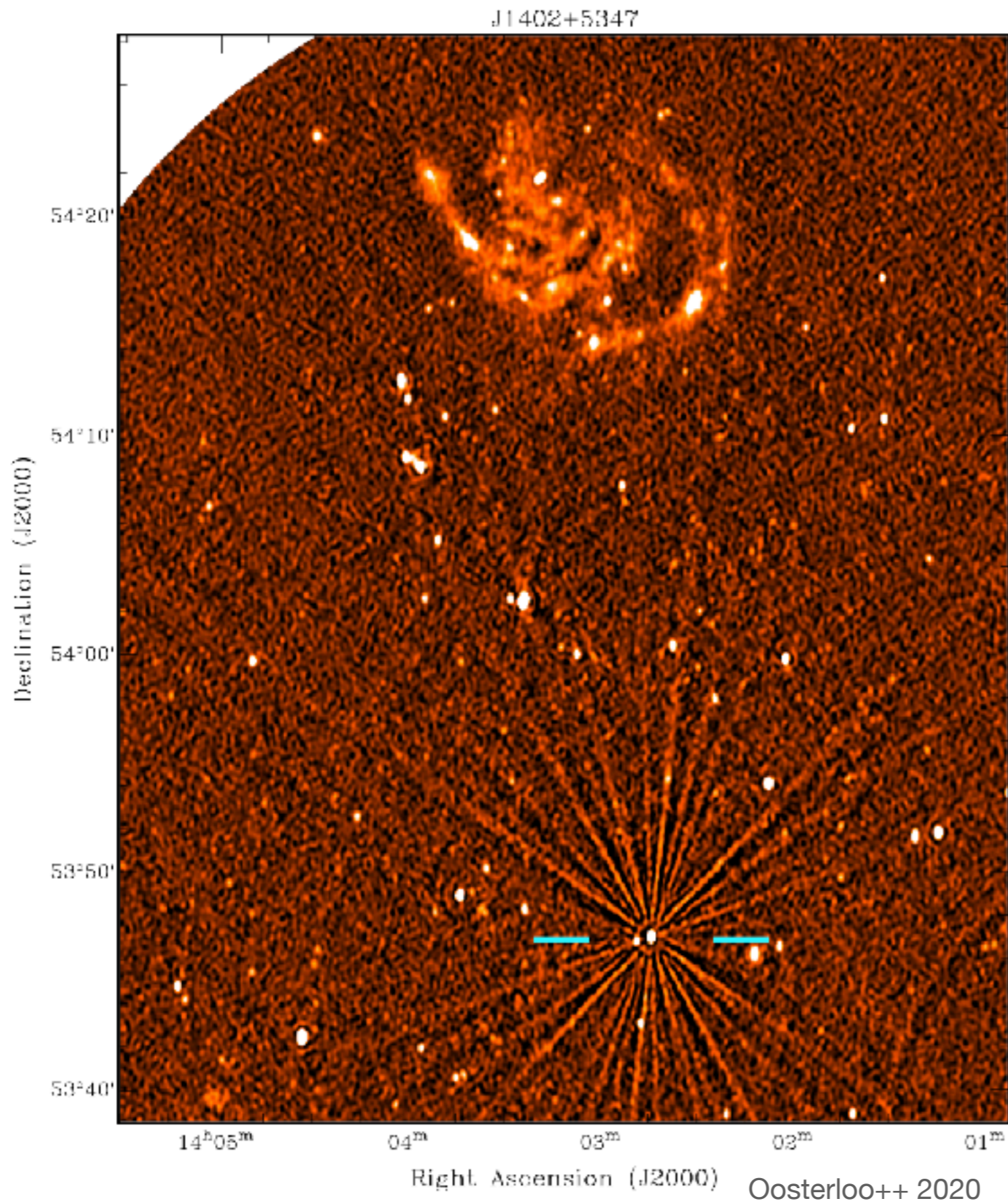
Thinking in Fourier space - what went wrong?



What are all these spikes?



What are all these spikes?



Think of wave interference next time you encounter

