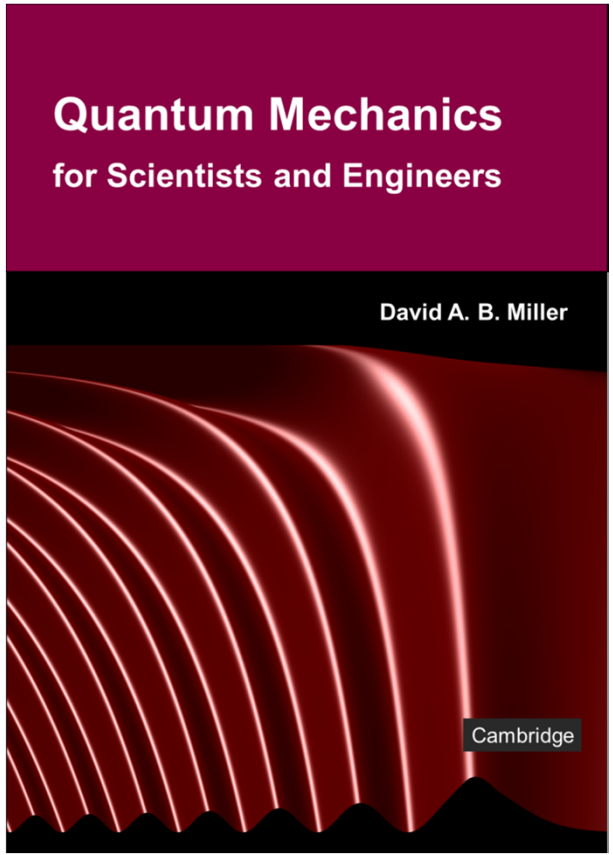
2.1 Wave propagation

Slides: Video 2.1.5 Diffraction from periodic structures

Text reference: Quantum Mechanics for Scientists and Engineers

Section B.4

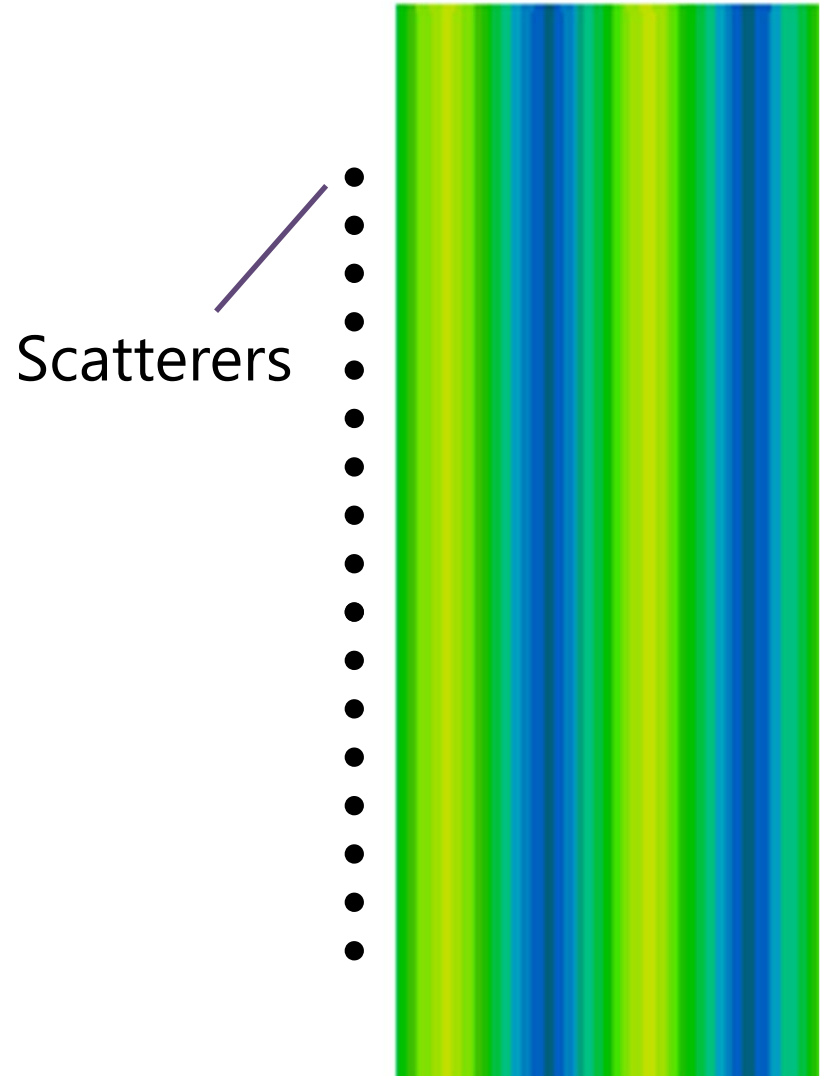


Wave propagation

Diffraction from periodic structures

Quantum mechanics for scientists and engineers

David Miller



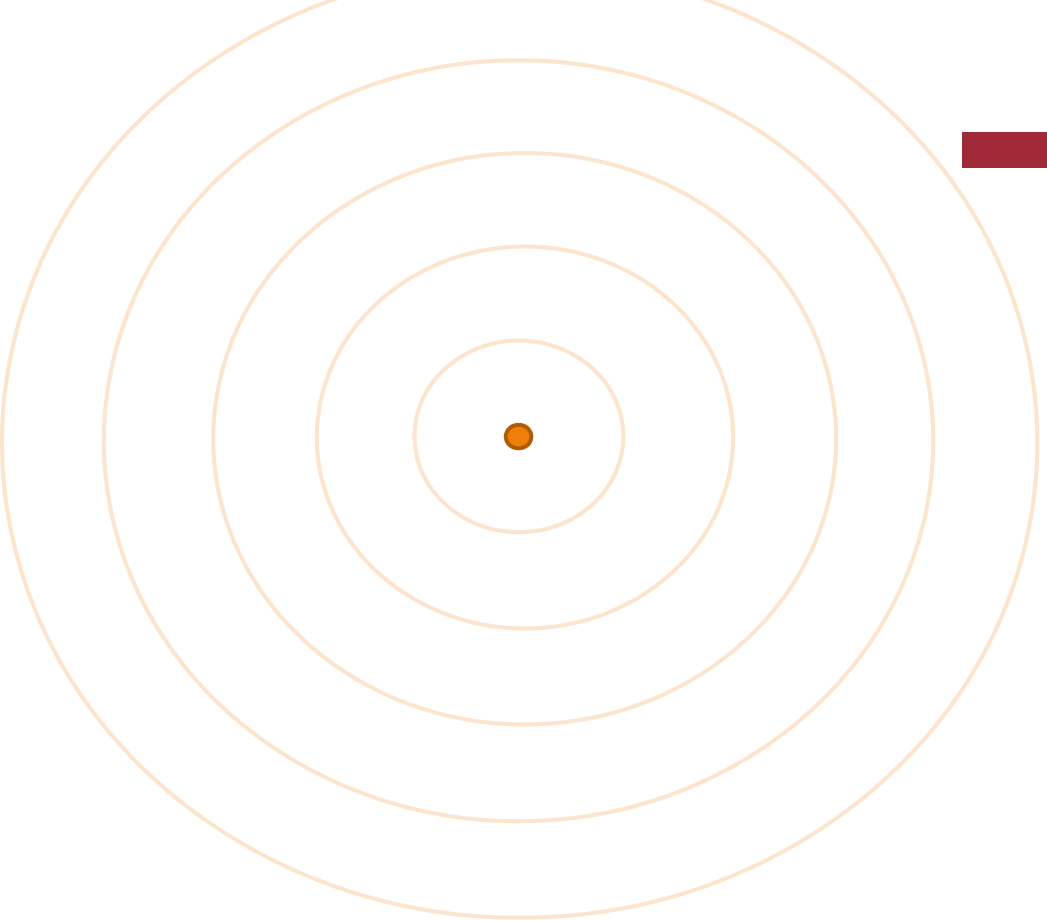
Periodic structures

Suppose we have a set of equally spaced identical scatterers

and we shine a monochromatic wave at them from the right

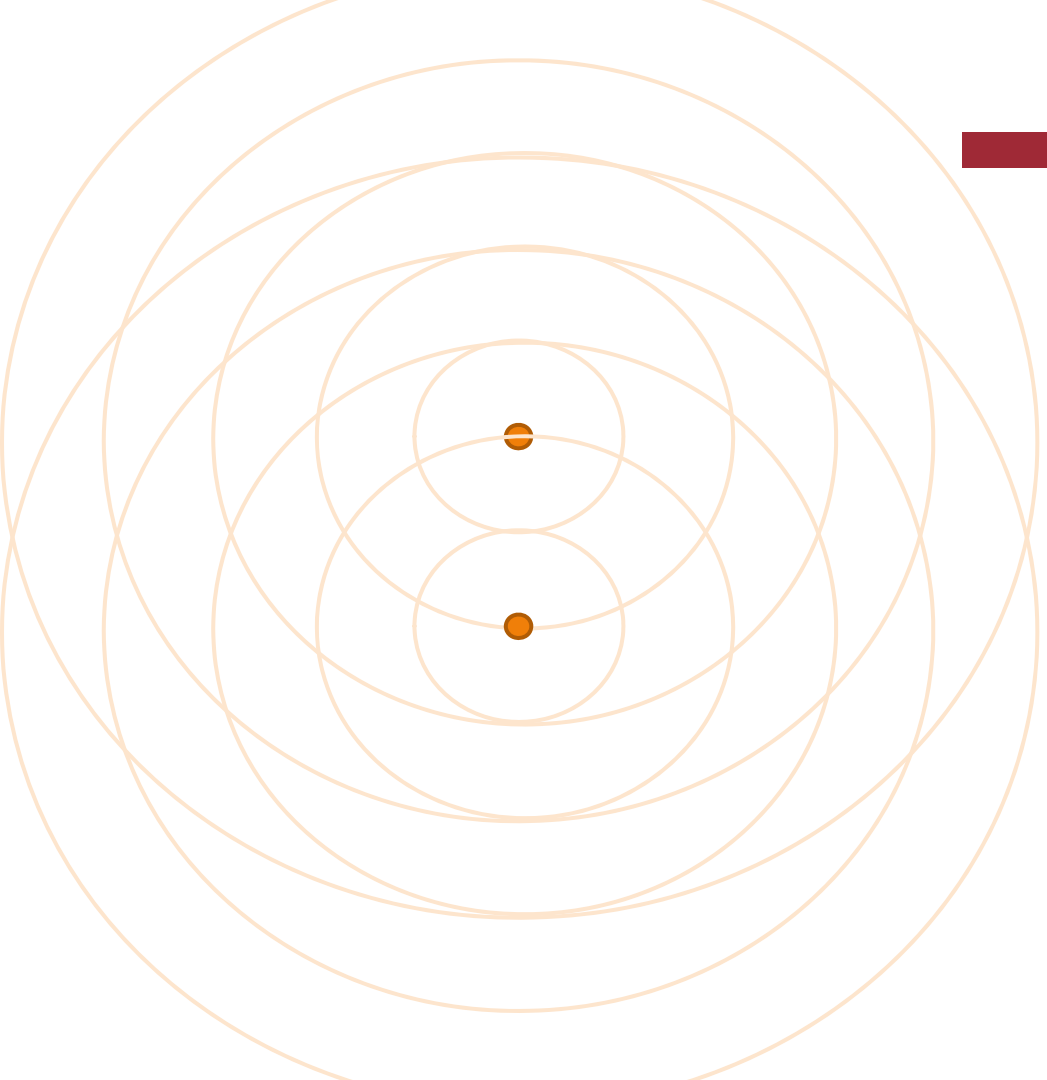
what does the back-scattered light look like?

Periodic structures



One scatterer will give a set of phase fronts

concentric “circles”



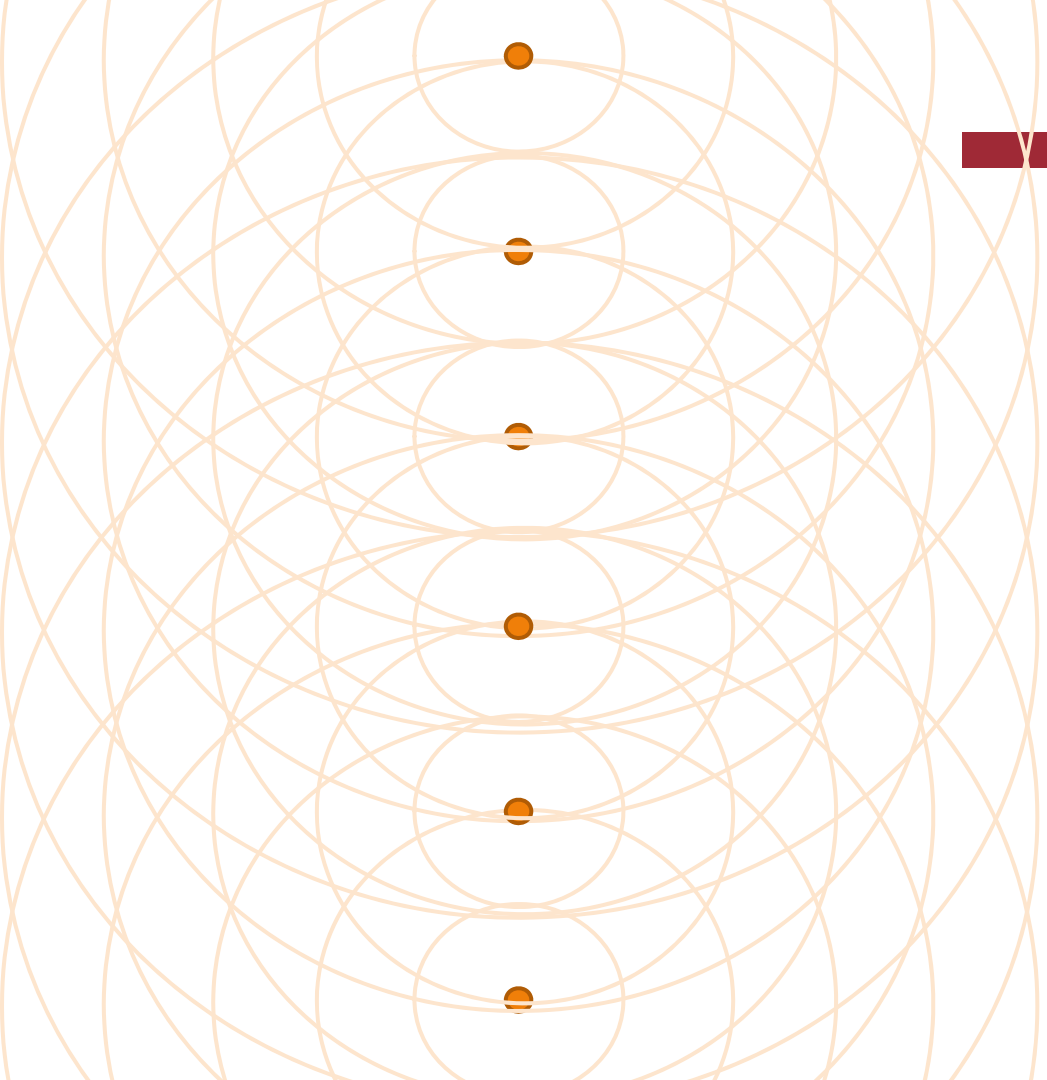
Periodic structures

One scatterer will give a set of phase fronts

concentric “circles”

Two will give two sets

which will interfere



Periodic structures

One scatterer will give a set of phase fronts

concentric “circles”

Two will give two sets

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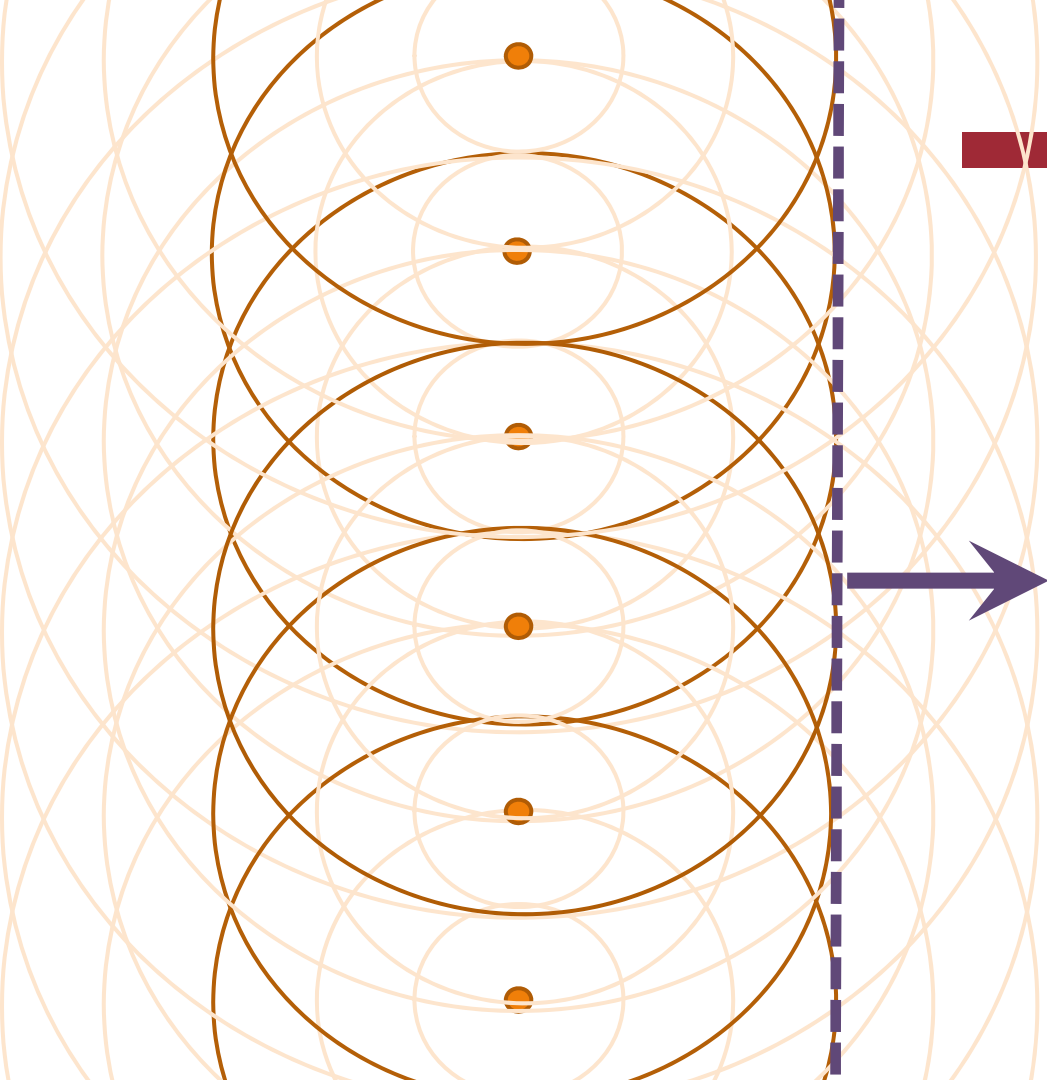
Multiple equally spaced scatterers give multiple sets



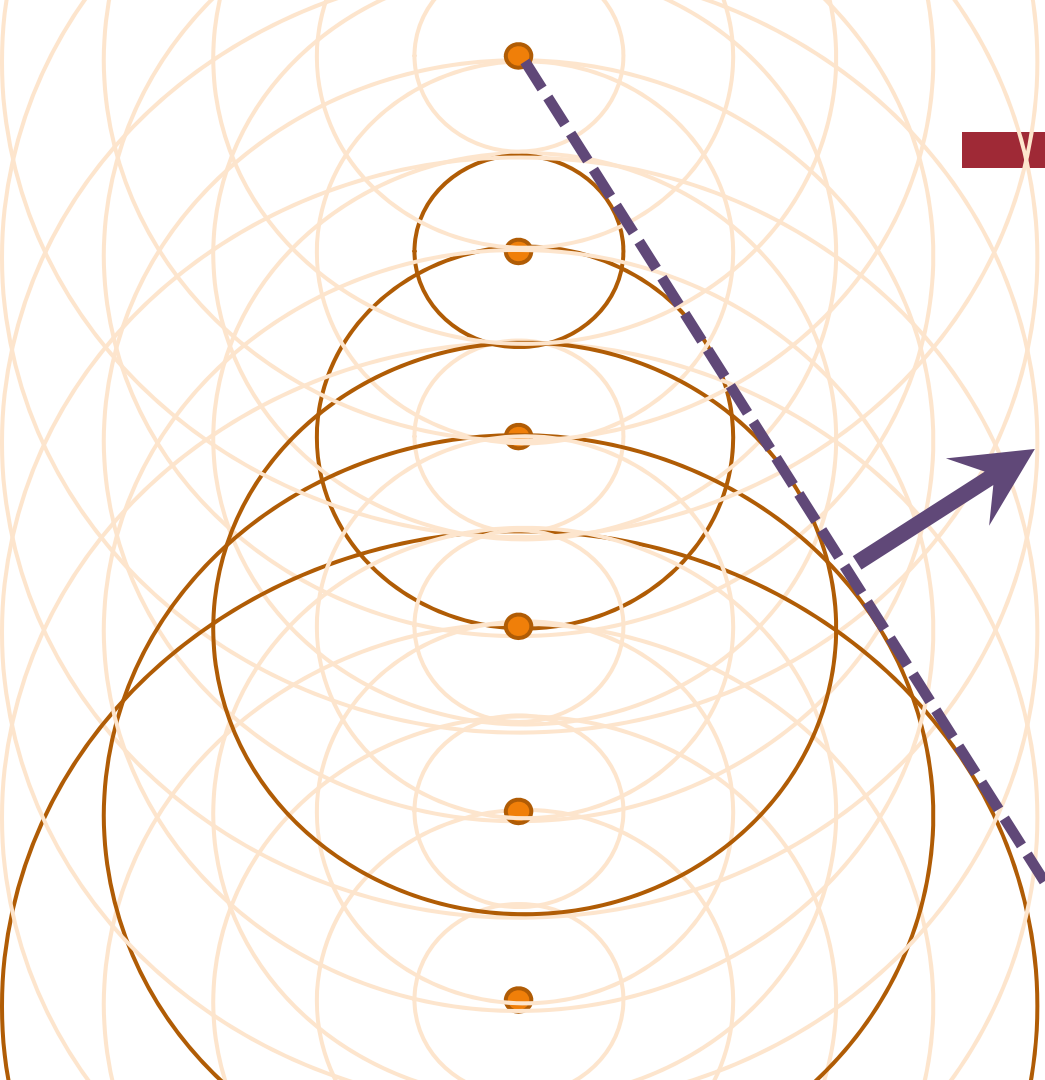
Periodic structures

These scatterers all add in phase for particular directions, here

"straight ahead"

called a "zeroth order" diffraction

Periodic structures



These scatterers all add in phase for particular directions, here

"straight ahead"

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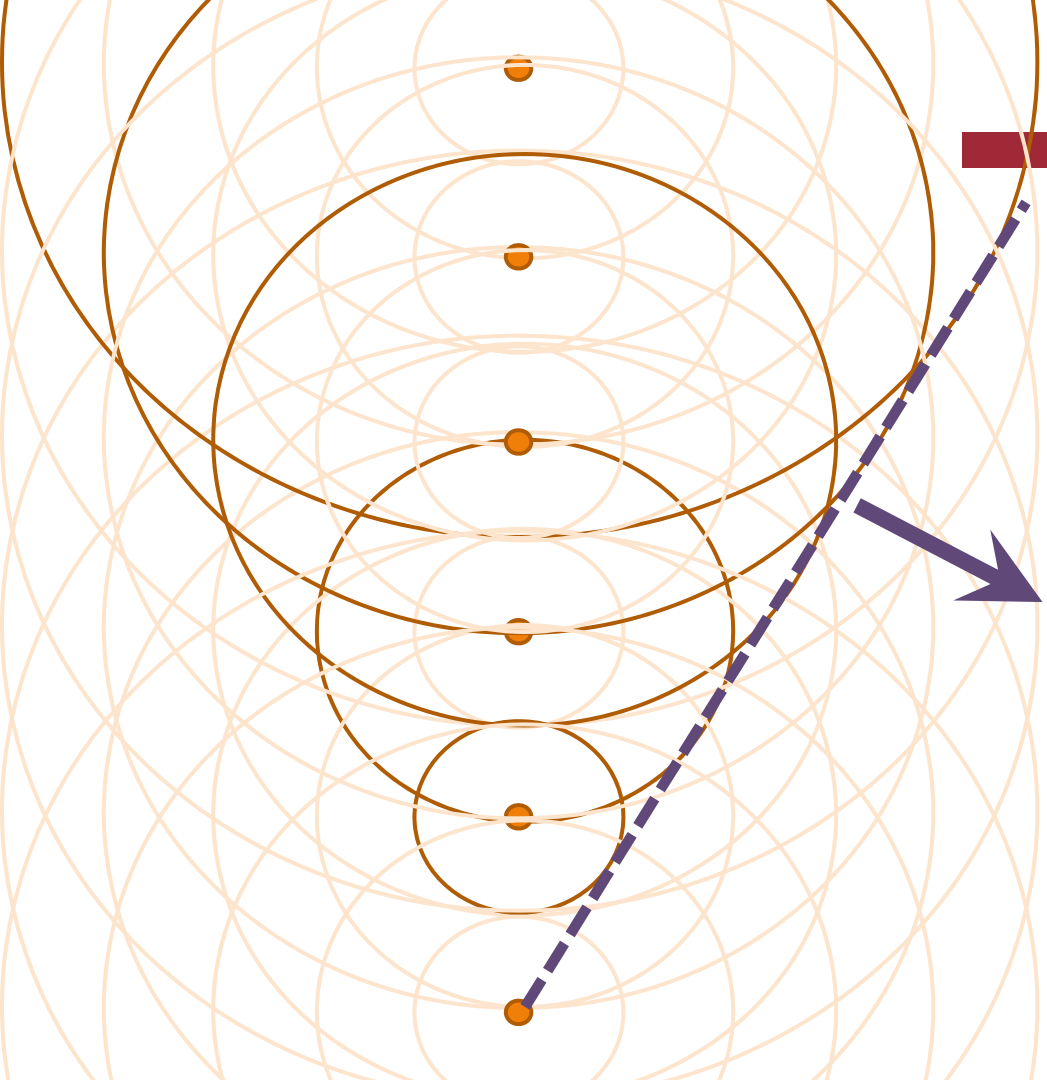
an upward direction



Periodic structures

These scatterers all add in phase for particular directions, here

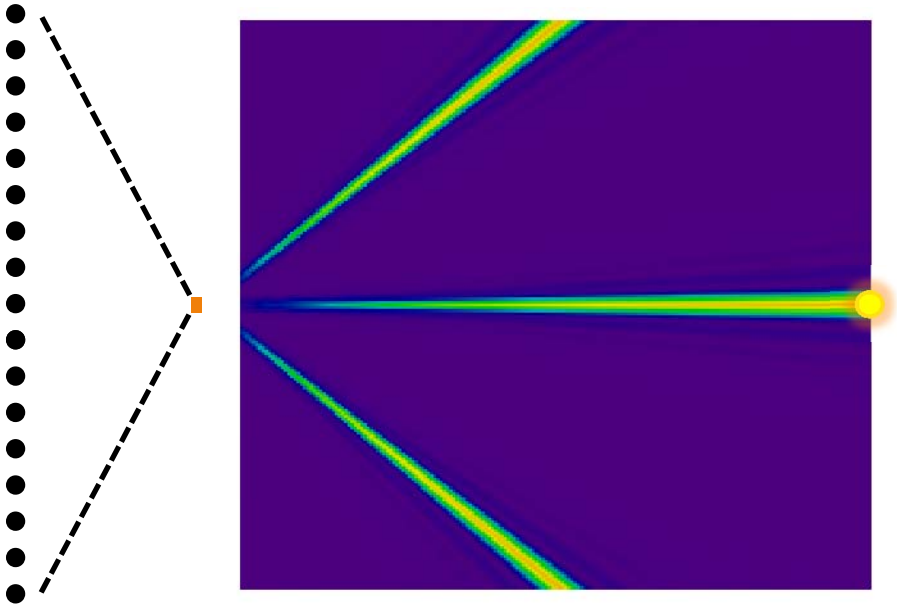
"straight ahead"

called a "zeroth order" diffraction

an upward direction

a downward direction

Periodic structures



At large distances from the scatterer

we get a multiple-beam diffraction pattern

which looks like a set of points on a screen

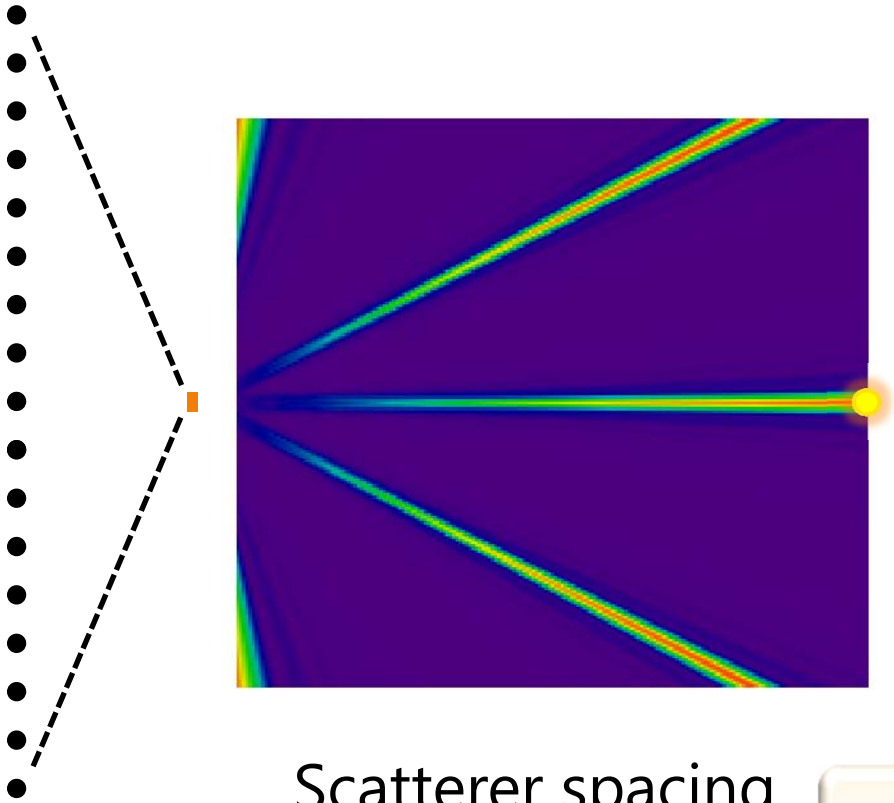
Larger scatterer separation

gives beams closer in angle

Scatterer spacing in wavelengths

1.5

Periodic structures



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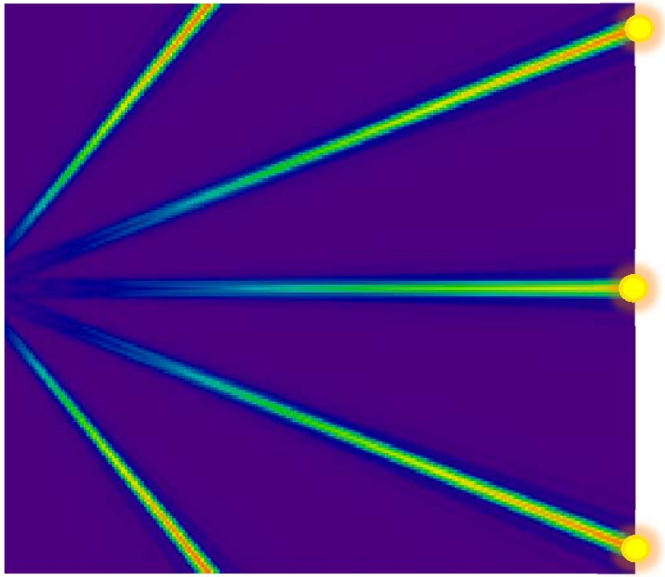
Scatterer spacing in wavelengths

2.0

Periodic structures



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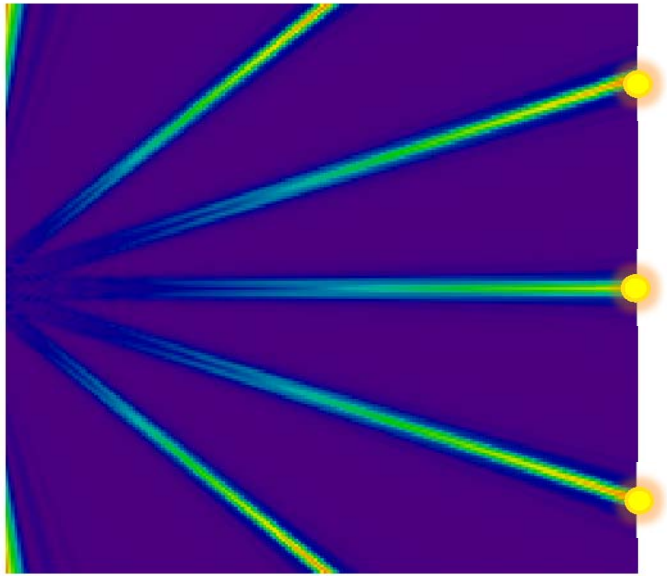
Periodic structures



At large distances from the scatterer

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Larger scatterer separation

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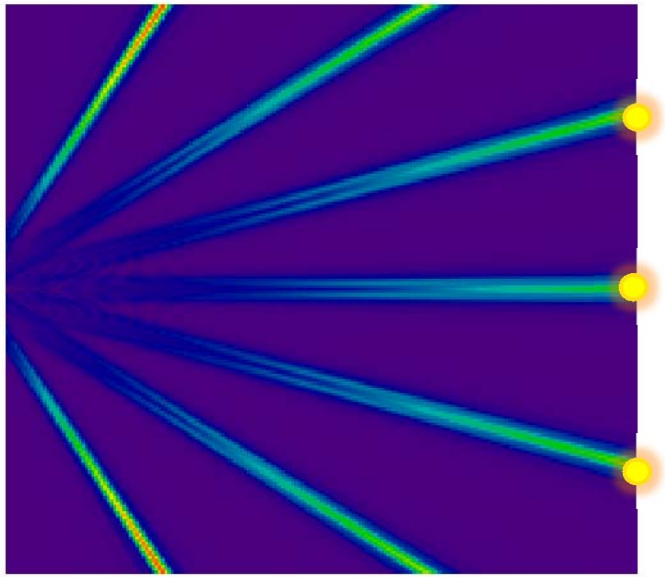
Scatterer spacing in wavelengths

3.0

Periodic structures



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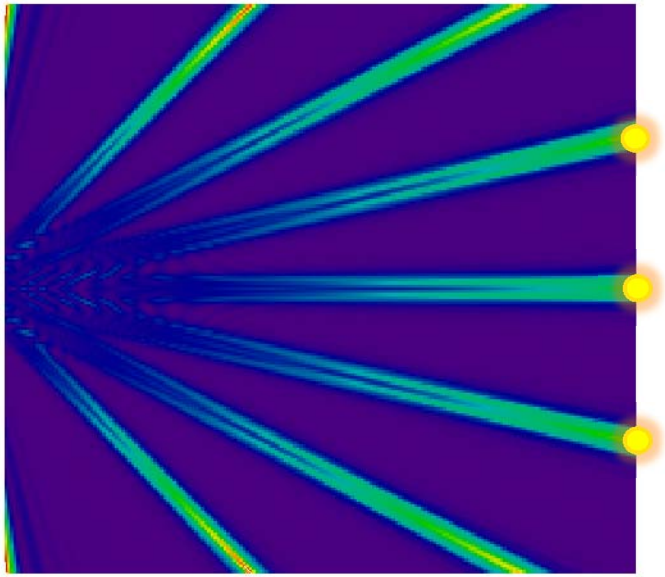
Periodic structures



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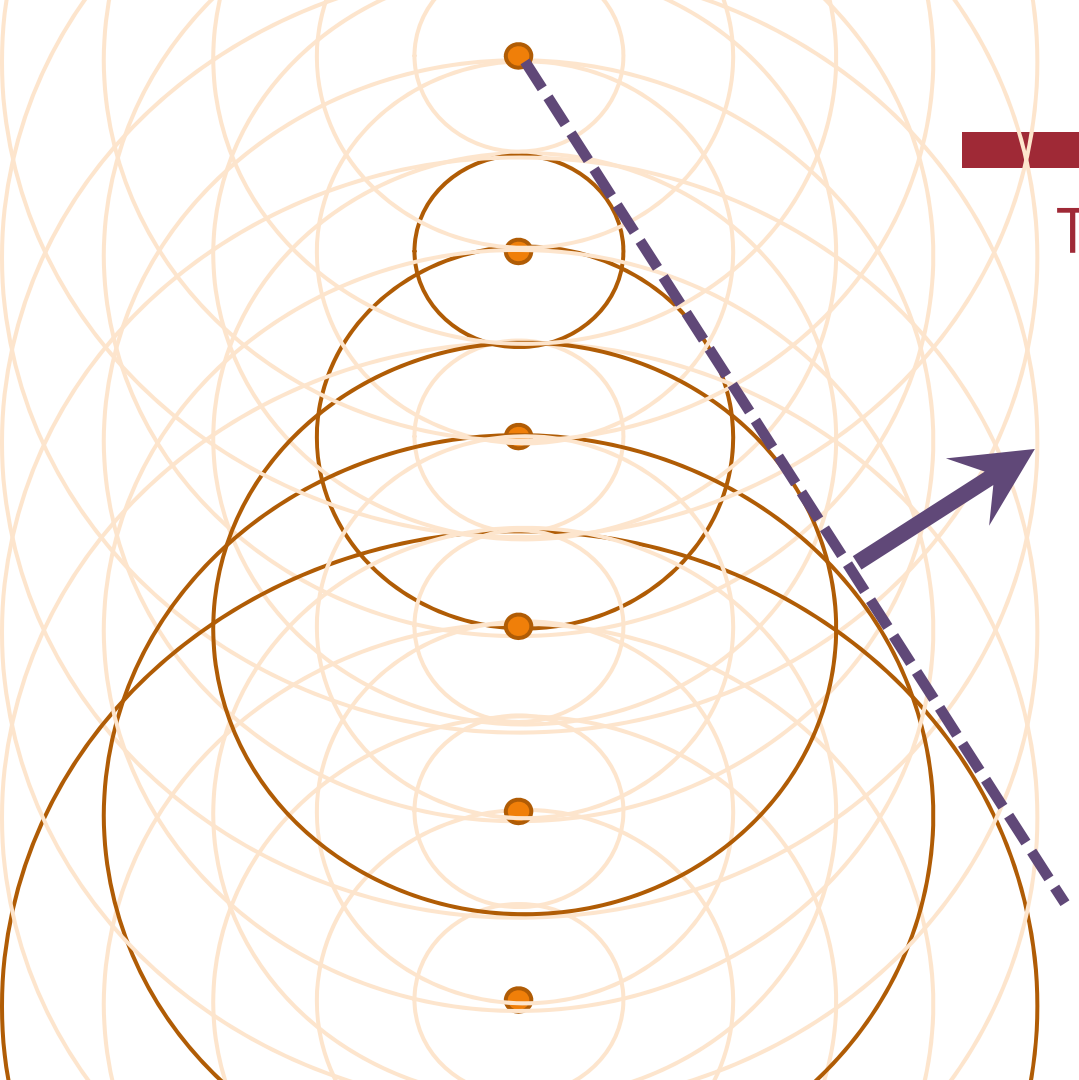
Scatterer spacing in wavelengths

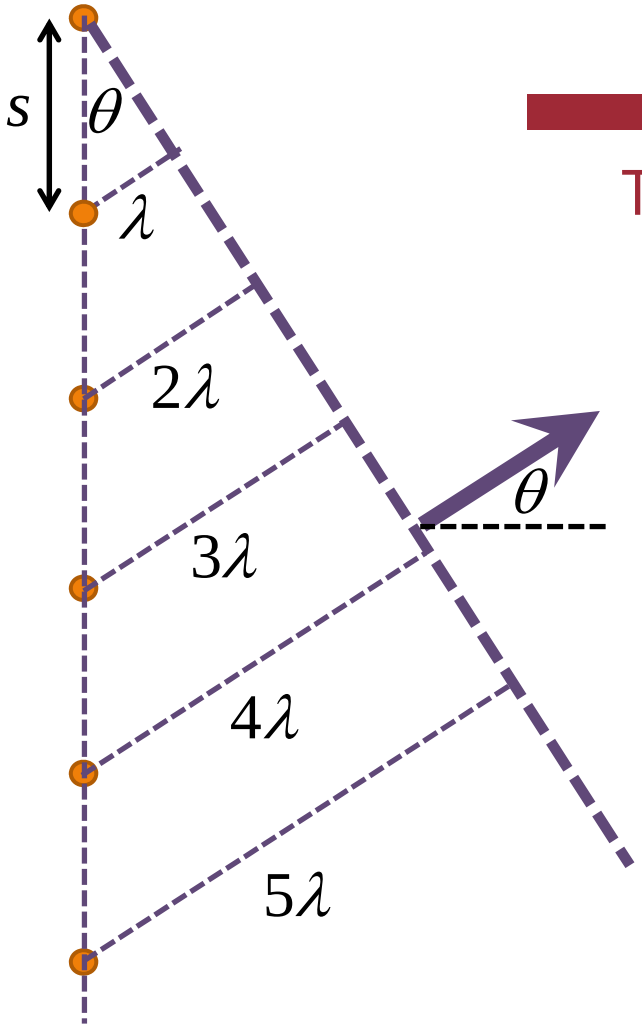
4.0

Periodic structures



The angle θ of these diffracted waves is given by simple geometry

Periodic structures



The angle θ of these diffracted waves is given by simple geometry

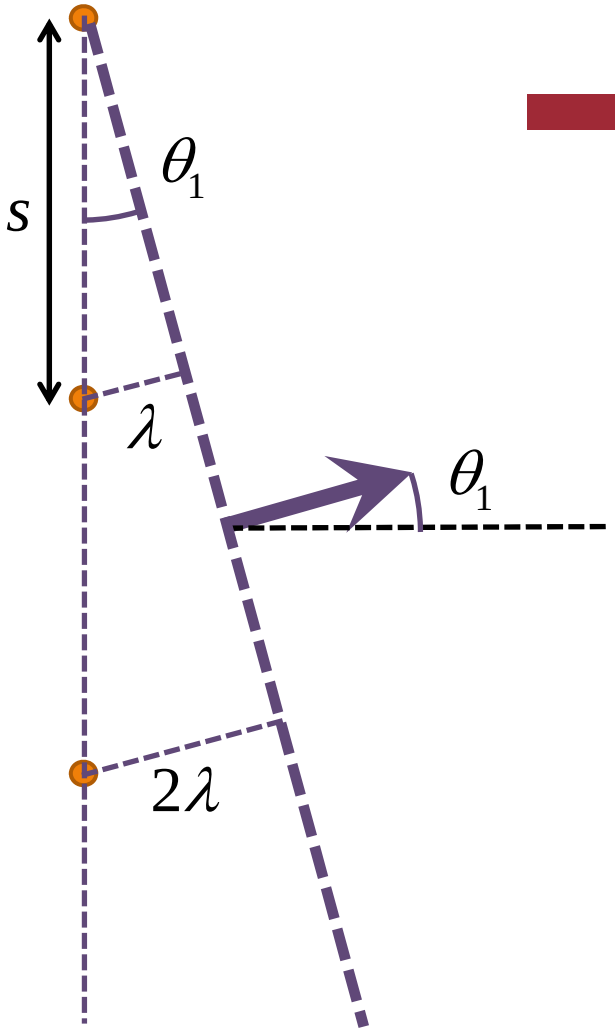
$$\sin\theta = \frac{\lambda}{s}$$

where

λ is the wavelength

s is the separation between scatterers

Periodic structures

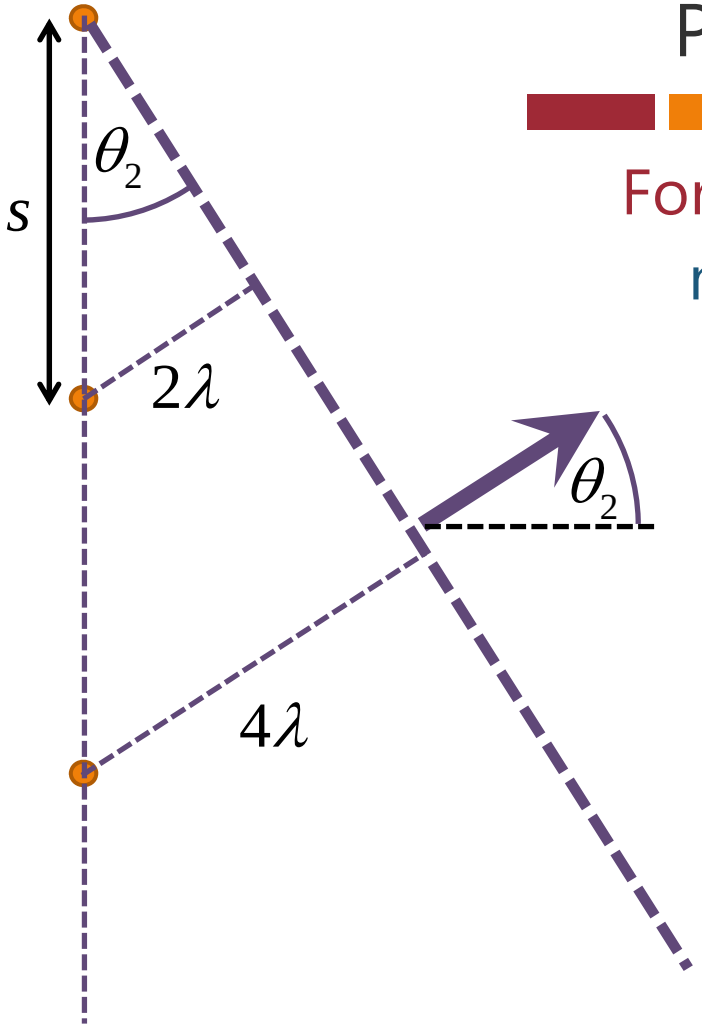


For larger spacings s multiple diffraction "orders" are possible

$$\sin\theta_1 = \frac{\lambda}{s}$$

is a "first order" diffraction

Periodic structures

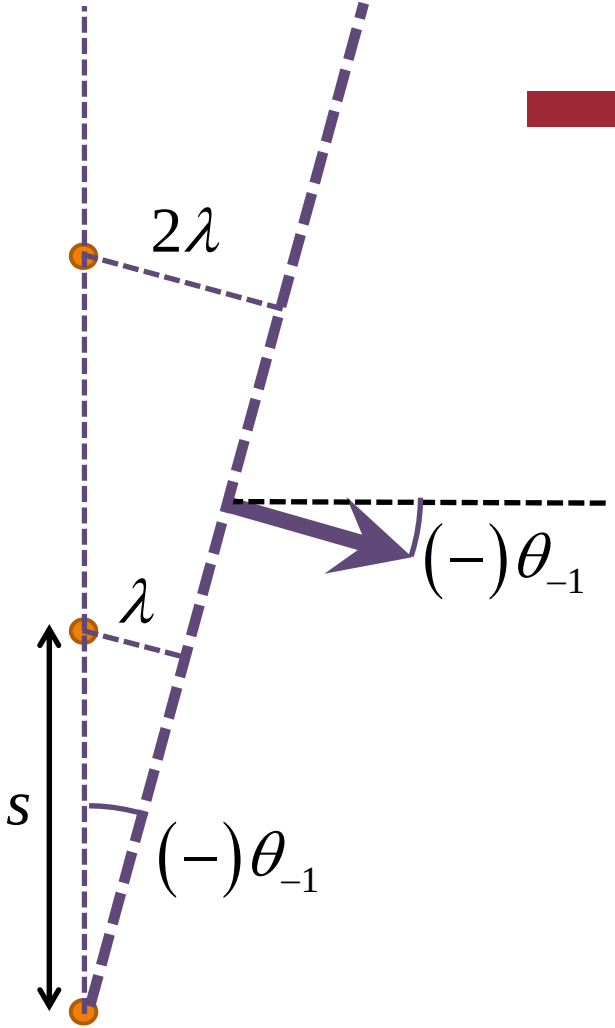


For larger spacings s multiple diffraction "orders" are possible

$$\sin\theta_2 = \frac{2\lambda}{s}$$

is a "second order" diffraction

Periodic structures



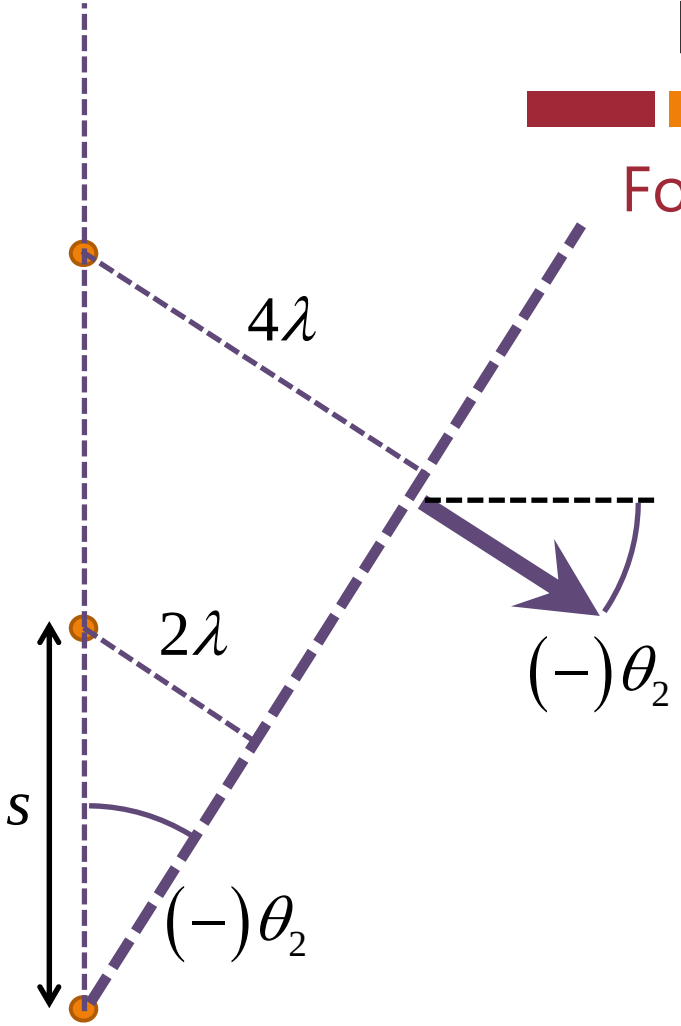
For larger spacings s
multiple diffraction
"orders" are possible

$$\sin\theta_{-1} = \frac{(-)\lambda}{s}$$

is a "(negative) first order" diffraction

the sign is a matter of taste for this "normal" incidence

Periodic structures



For larger spacings s

multiple diffraction "orders" are possible

$$\sin\theta_{-2} = \frac{(-)2\lambda}{s}$$

is a "(negative) second order" diffraction

the sign is a matter of taste for this "normal" incidence