2-D Patterns & Diffraction

More with Interference…

Light: Interference and Optics

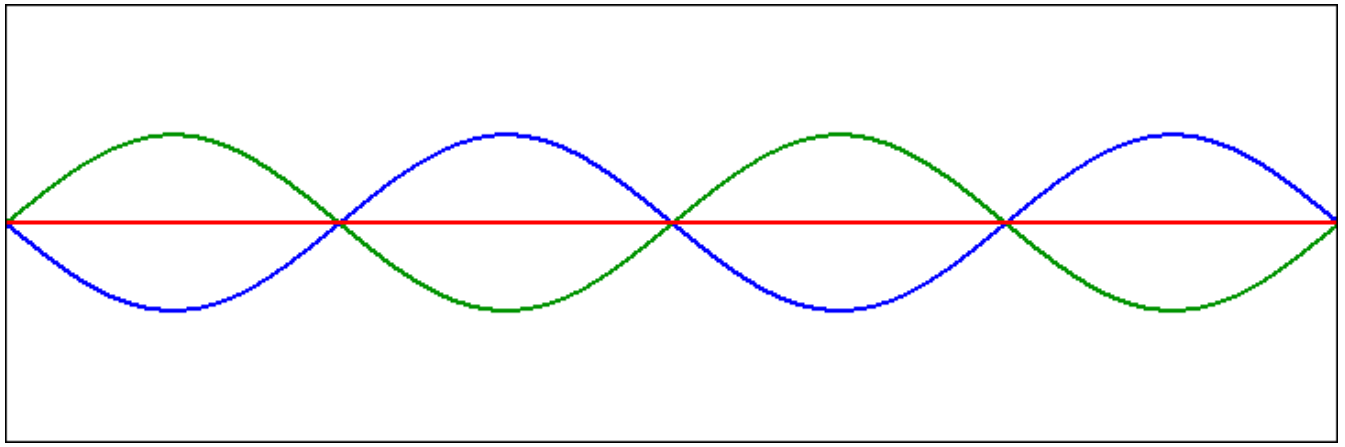
I. Light as a Wave
   - wave basics review
   - electromagnetic radiation

II. Diffraction and Interference
   - diffraction, Huygen's principle
   - superposition, interference
   - standing waves, slits & gratings

III. Geometric Optics
   - reflection, refraction, Snell's Law
   - images, lenses, and mirrors

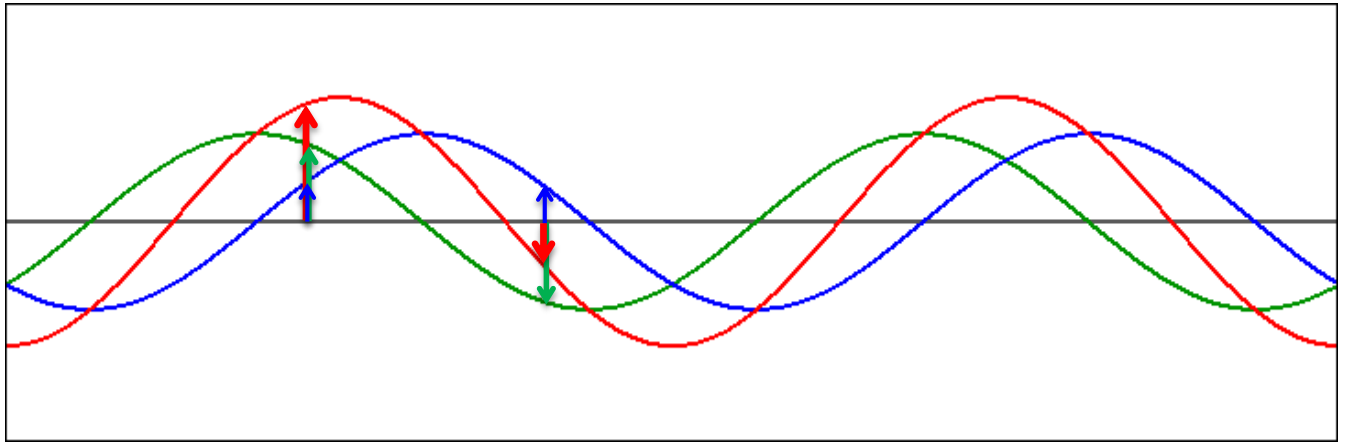
	The student will be able to:	HW:
1	Model light and other types of electromagnetic radiation as a transverse wave of electric and magnetic fields and analyze graphs and/or functions to solve related problems and explain related phenomena such as polarization, absorption, production, intensity, etc. ✓	1 – 5
2	Model diffraction and interference of light involving slits or gratings by Huygen's principle and analyze and solve problems relating geometry of openings to patterns of interference.	6 – 18
3	State and apply laws of reflection and refraction, Snell's Law, and solve related problems and/or describe qualitatively the phenomena of absorption, transmission, and reflection of light undergoing a change in medium.	19 – 25
4	Apply the ray model of light to explain and analyze formation of real and virtual images by plane, concave, and convex mirrors and solve related problems involving object and image distance, magnification, focal length and/or radius of curvature.	26 – 31
5	Apply the ray model of light to explain and analyze formation of real and virtual images by converging or diverging thin lenses and solve related problems involving object and image distance, magnification, focal length and/or radius of curvature.	32 – 36

destructive interference

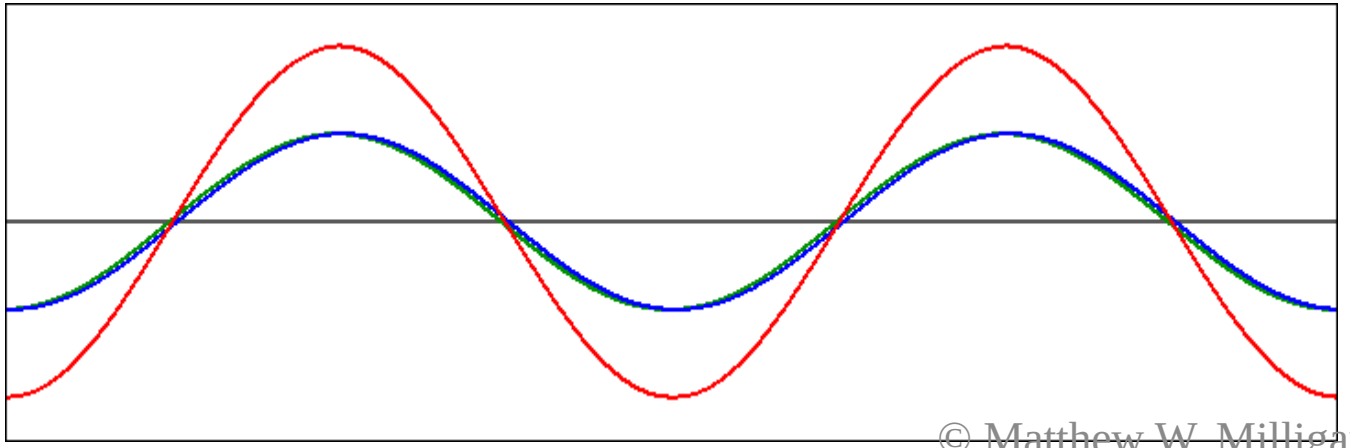


superposition principle:

$y_{net} = y_1 + y_2$



constructive interference

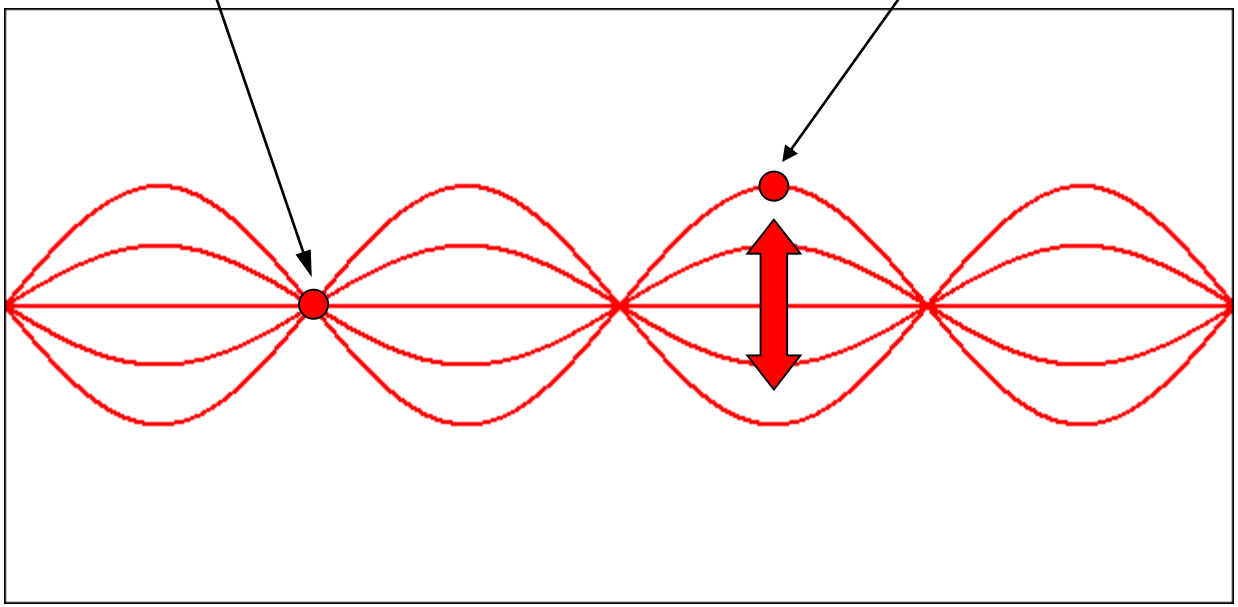


Standing Wave

- A **standing wave** is a pattern of interference caused by two identical waves traveling in opposite directions.
- The resulting pattern is stationary, hence the term “standing”.
- Most often standing waves are caused by reflection of a wave back upon itself.
- Standing waves are the basis for all musical instruments.

A **node** is a point of zero disturbance.

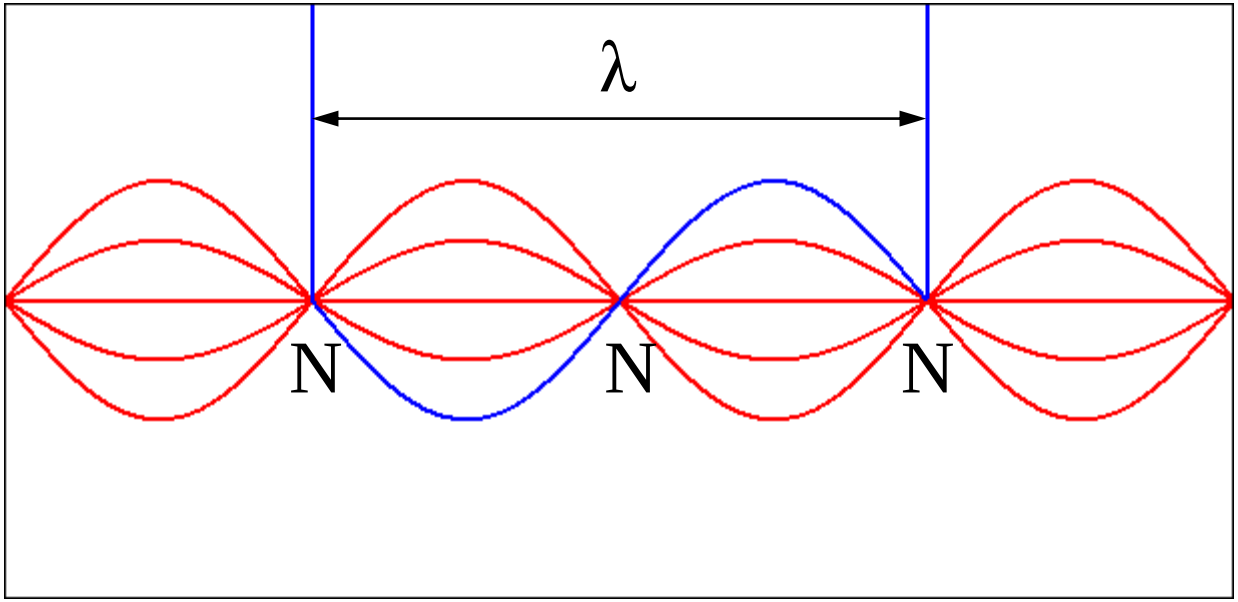
An **antinode** is a point that has maximum oscillation.



Destructive interference occurs at each node.

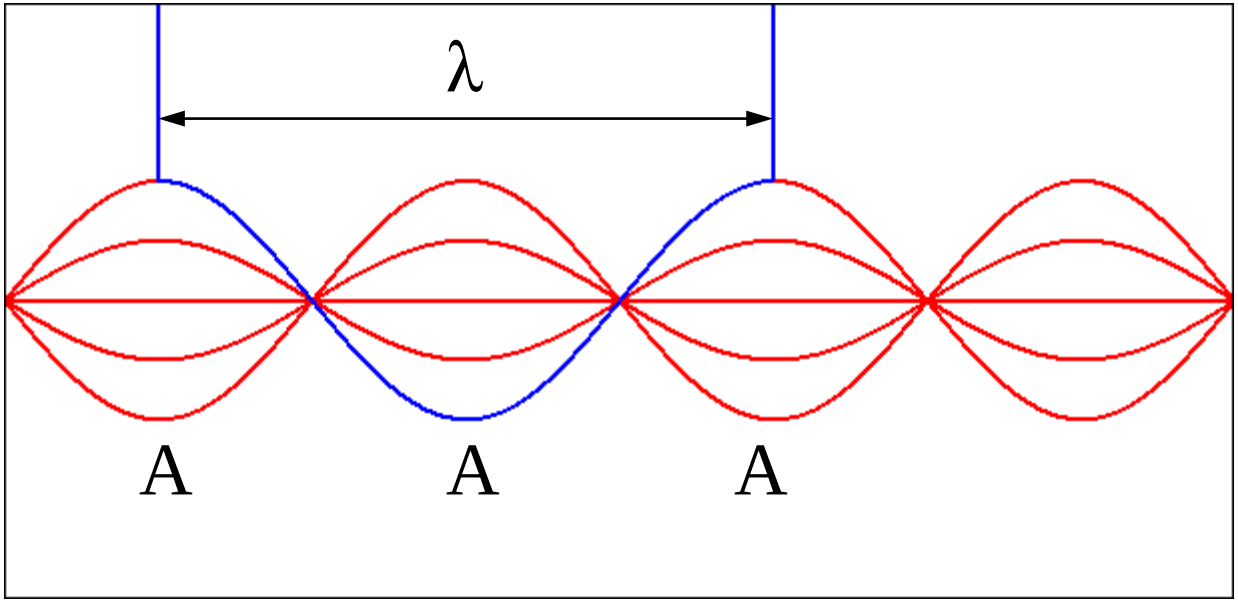
Constructive interference occurs at each antinode.

What is the wavelength of a standing wave?



The wavelength of a standing wave is twice the distance between successive nodes.

What is the wavelength of a standing wave?



The wavelength of a standing wave is twice the distance between successive antinodes.

2-D Interference Patterns

- If waves from two different sources spread out through a certain medium, a pattern of nodal and antinodal “lines” may occur.
- A common situation of interest is the pattern formed by two point sources acting in phase…

Diffraction

- Diffraction is the “bending” or “spreading” of a wave around the edge of a barrier.
- The effect is more pronounced the longer the wavelength relative to the dimensions of the barrier.
- Huygen’s principle states that each point along a wavefront acts as a point source. Successive wavefronts are the resulting superposition.

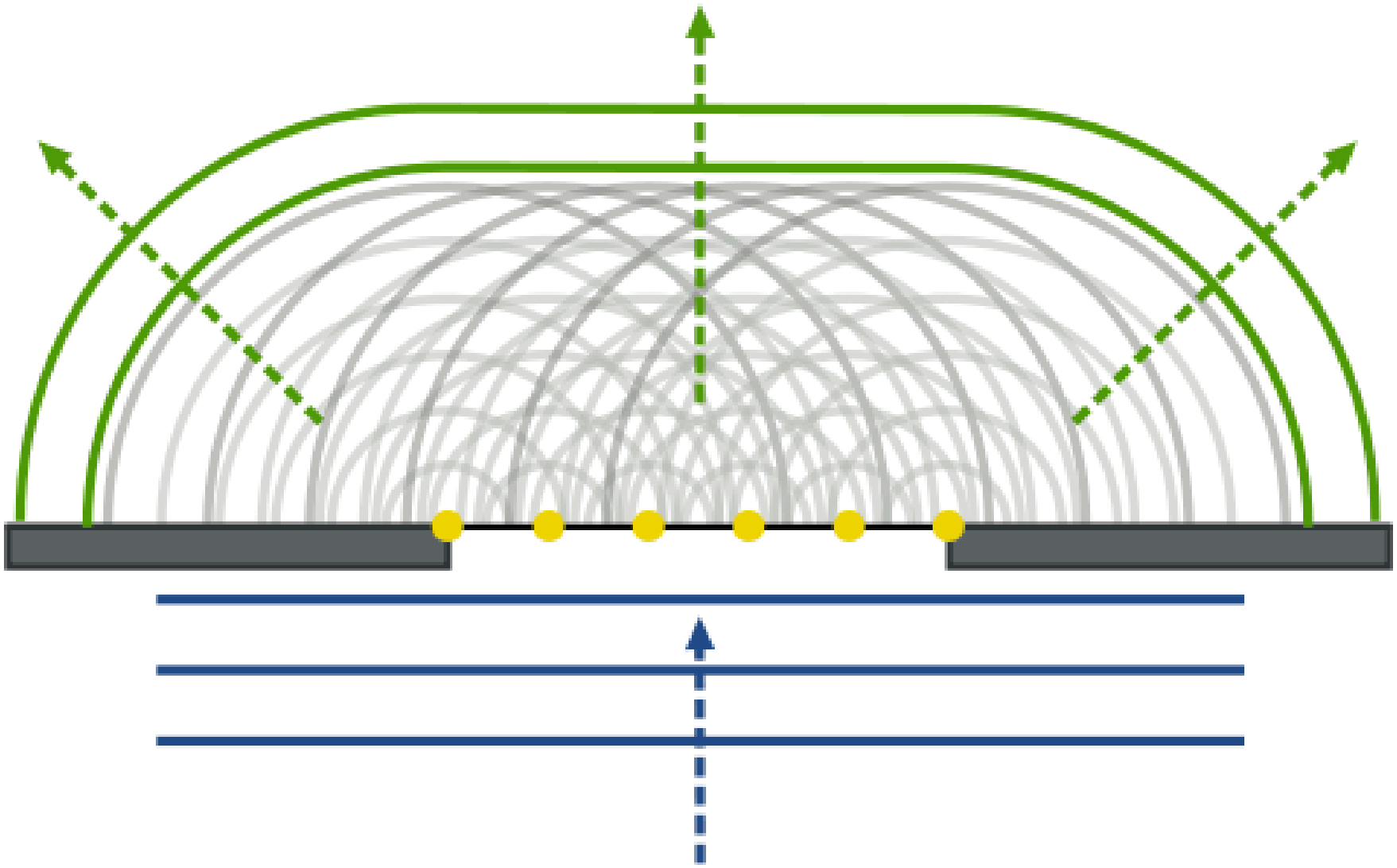
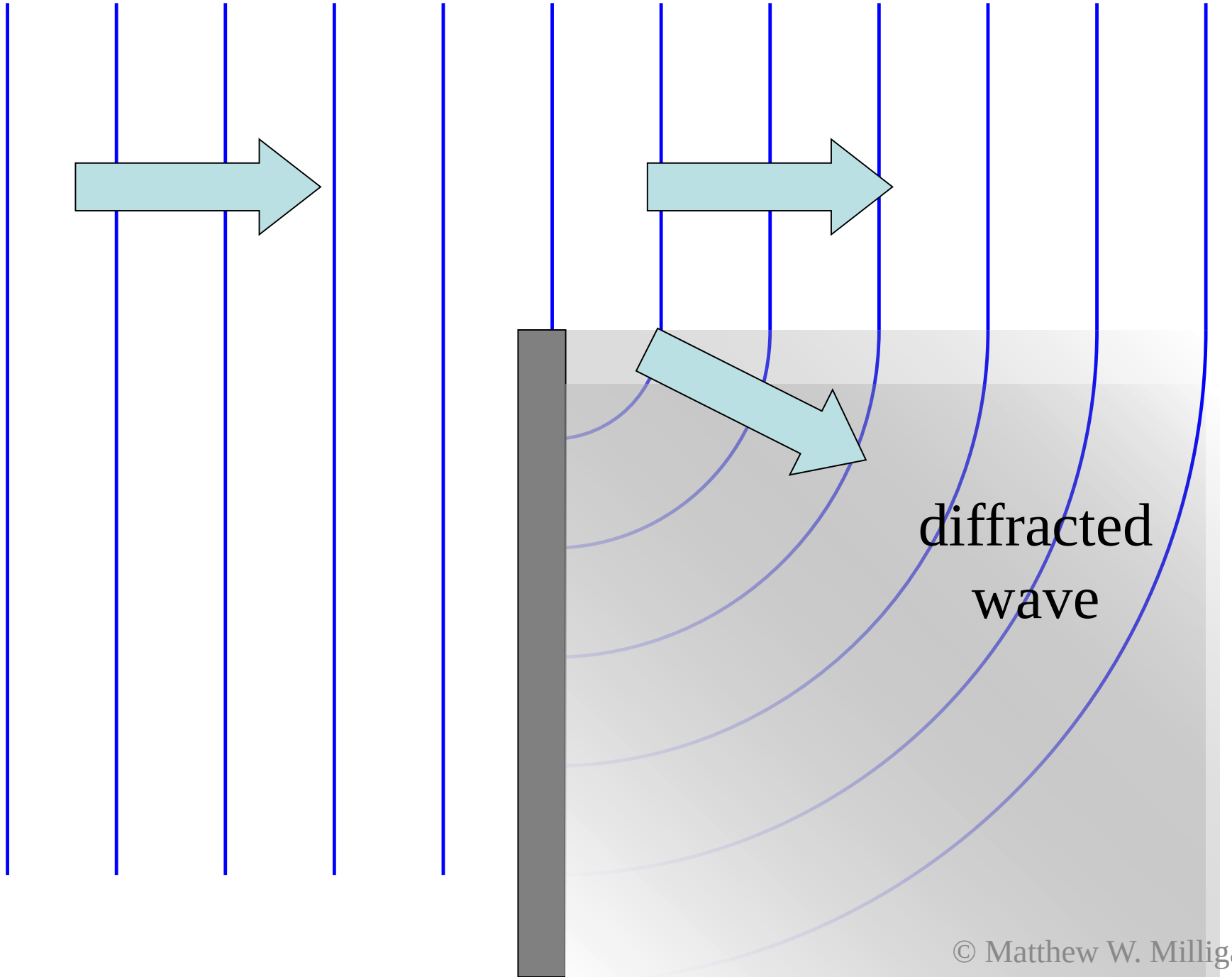
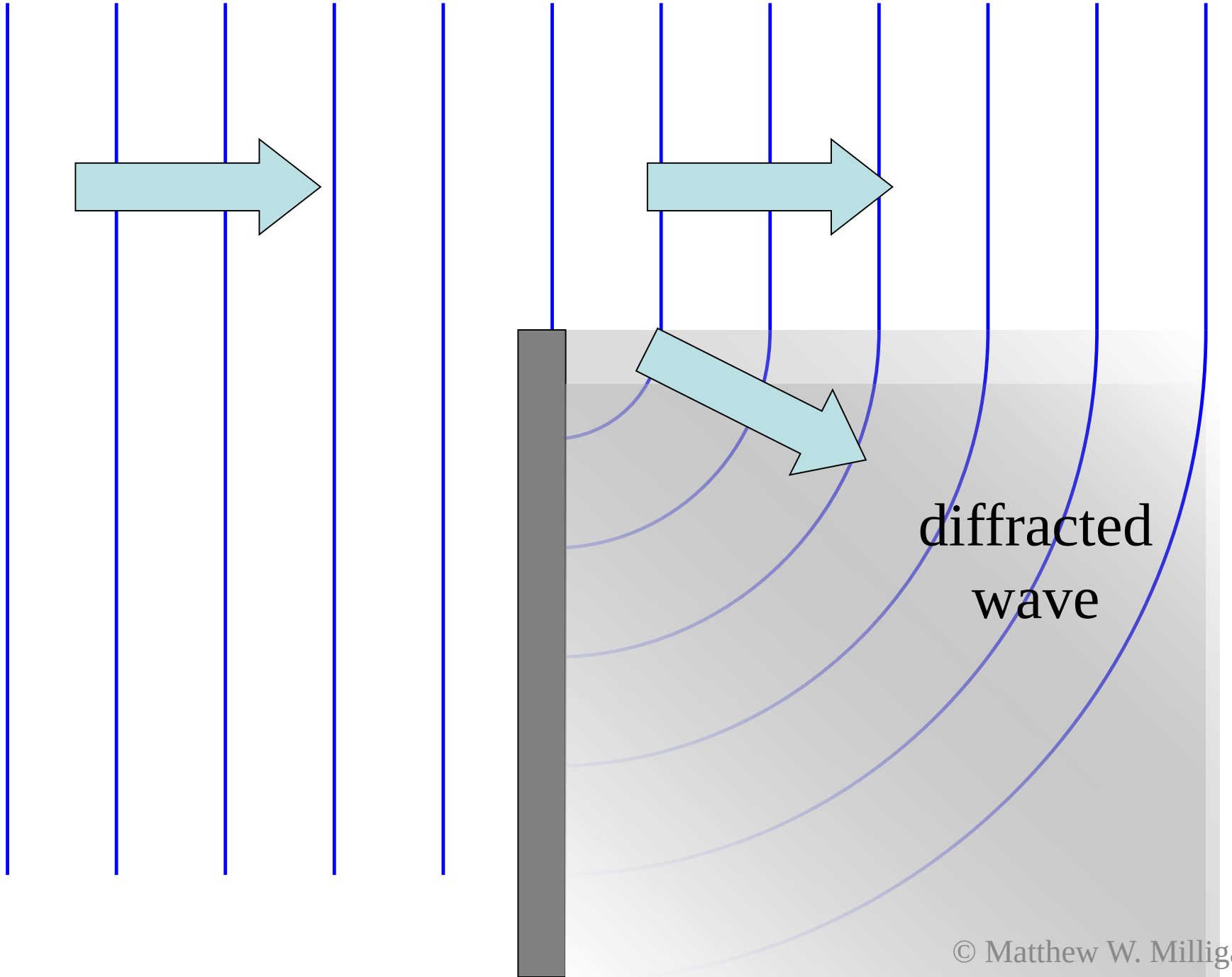
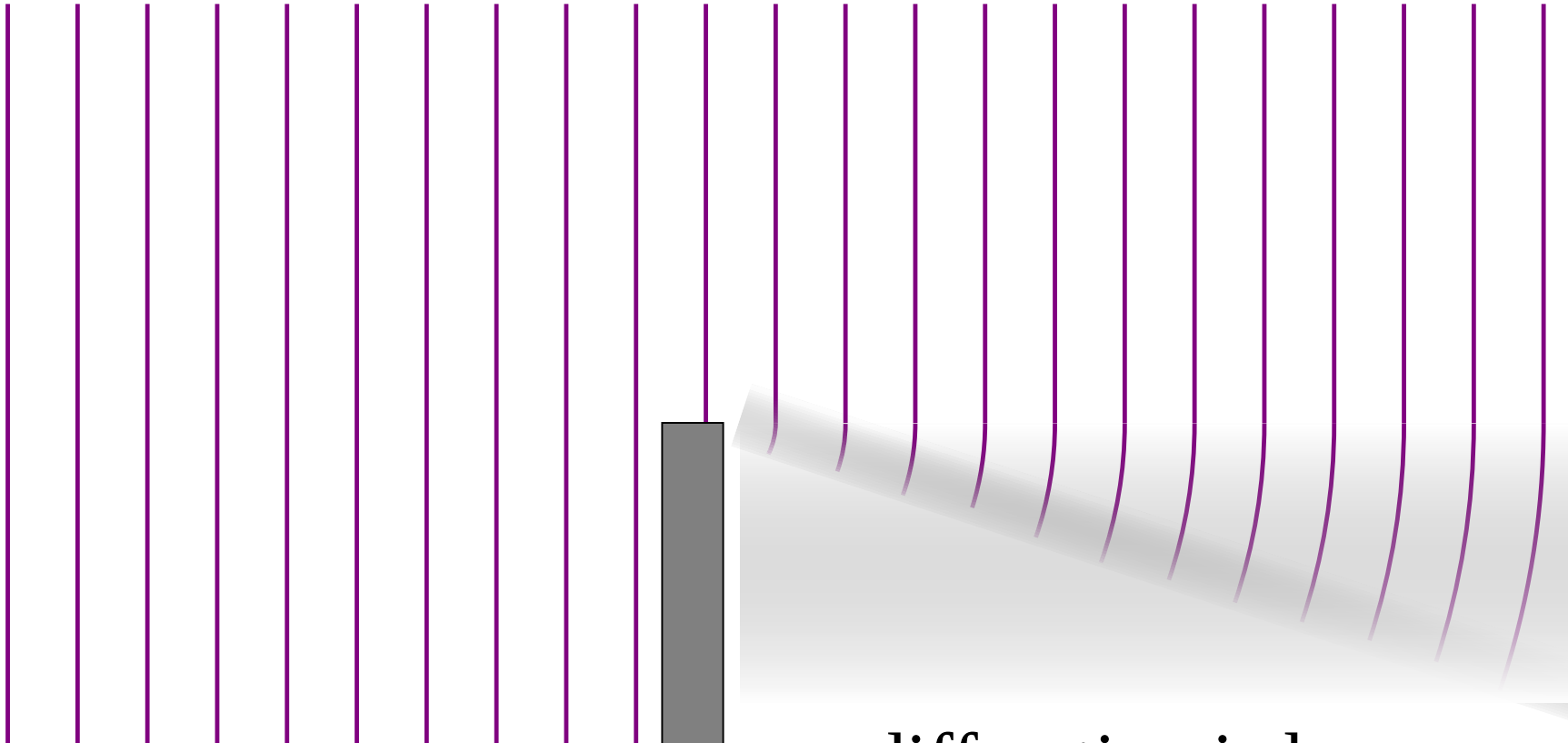


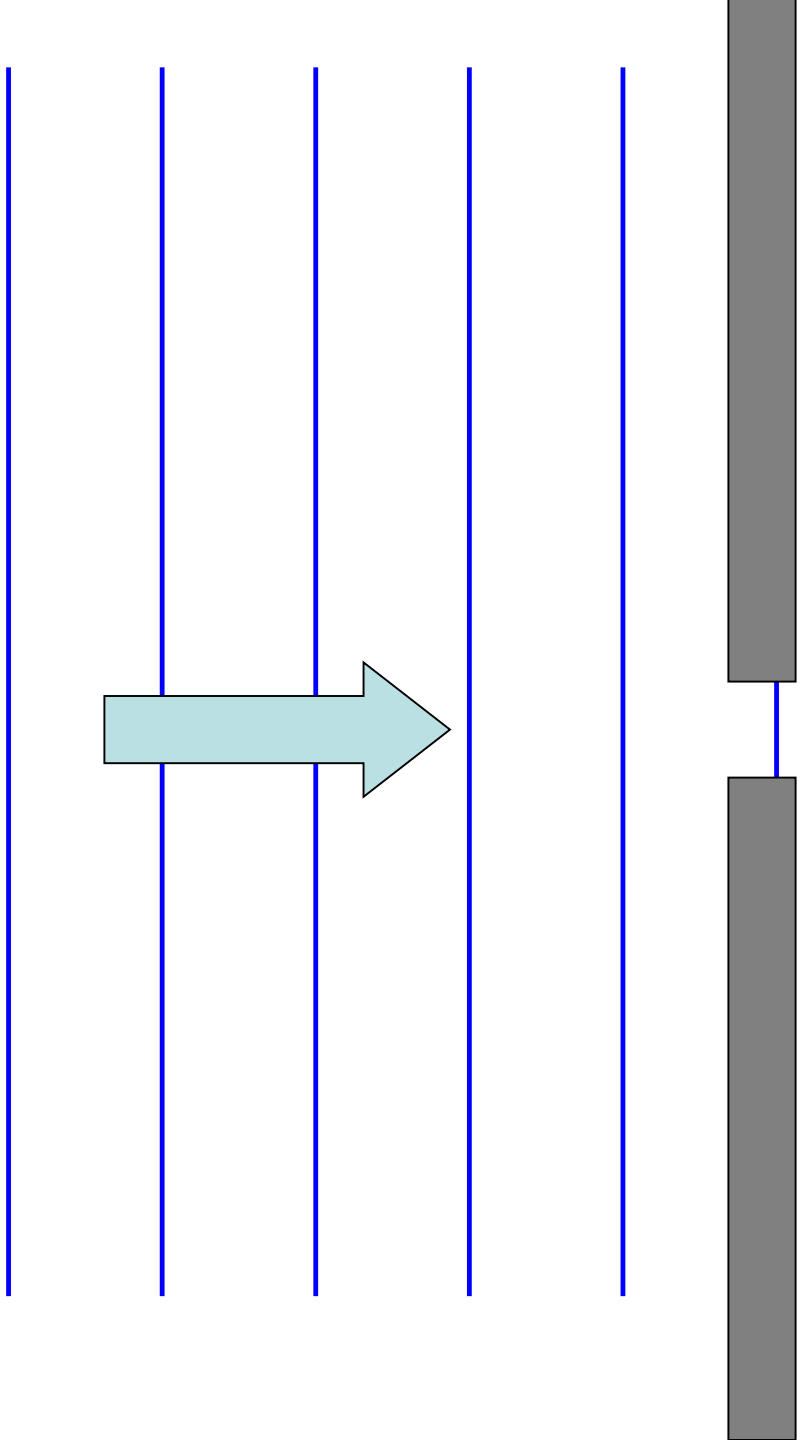
image credit : Arne Nordmann, Wikipedia



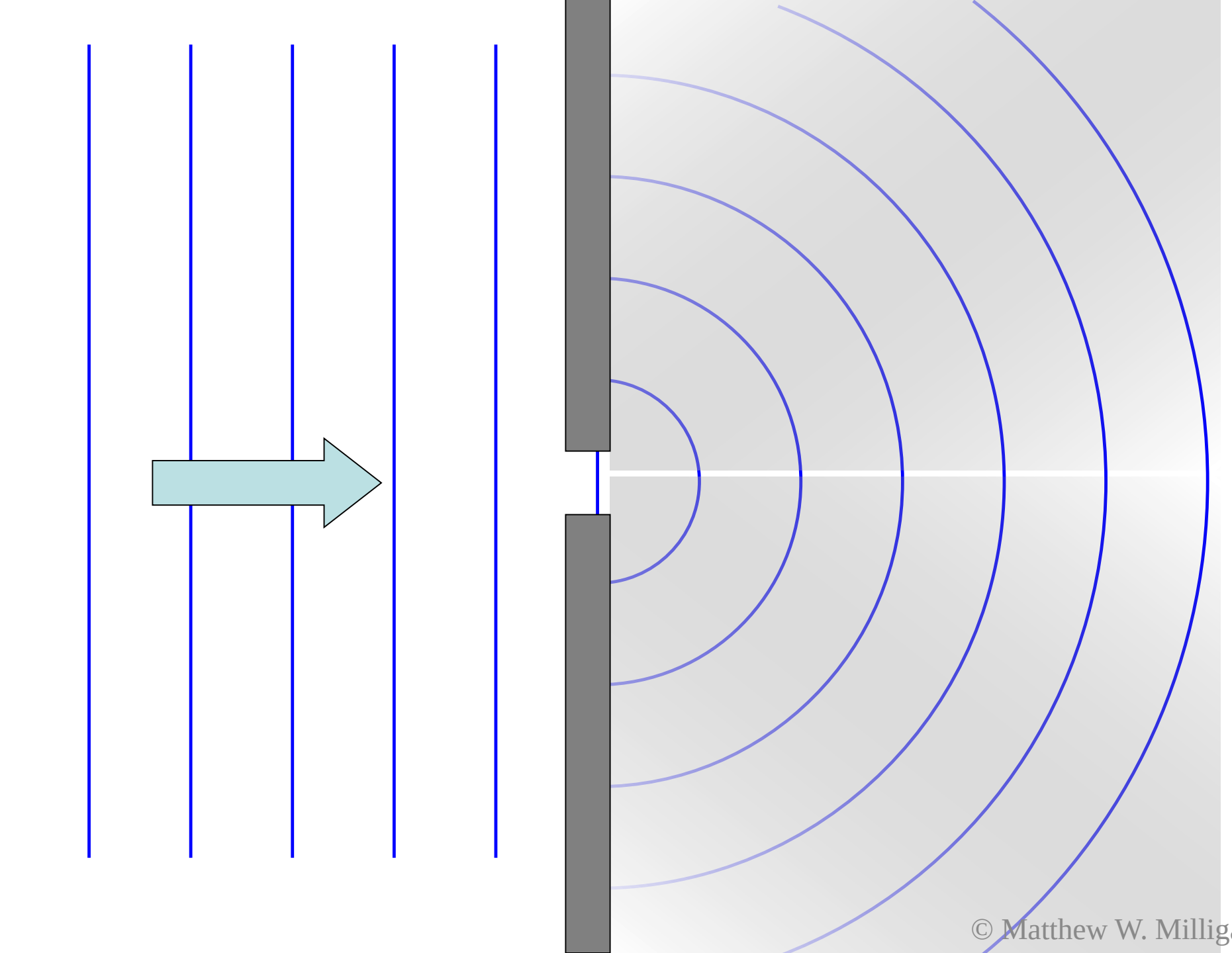


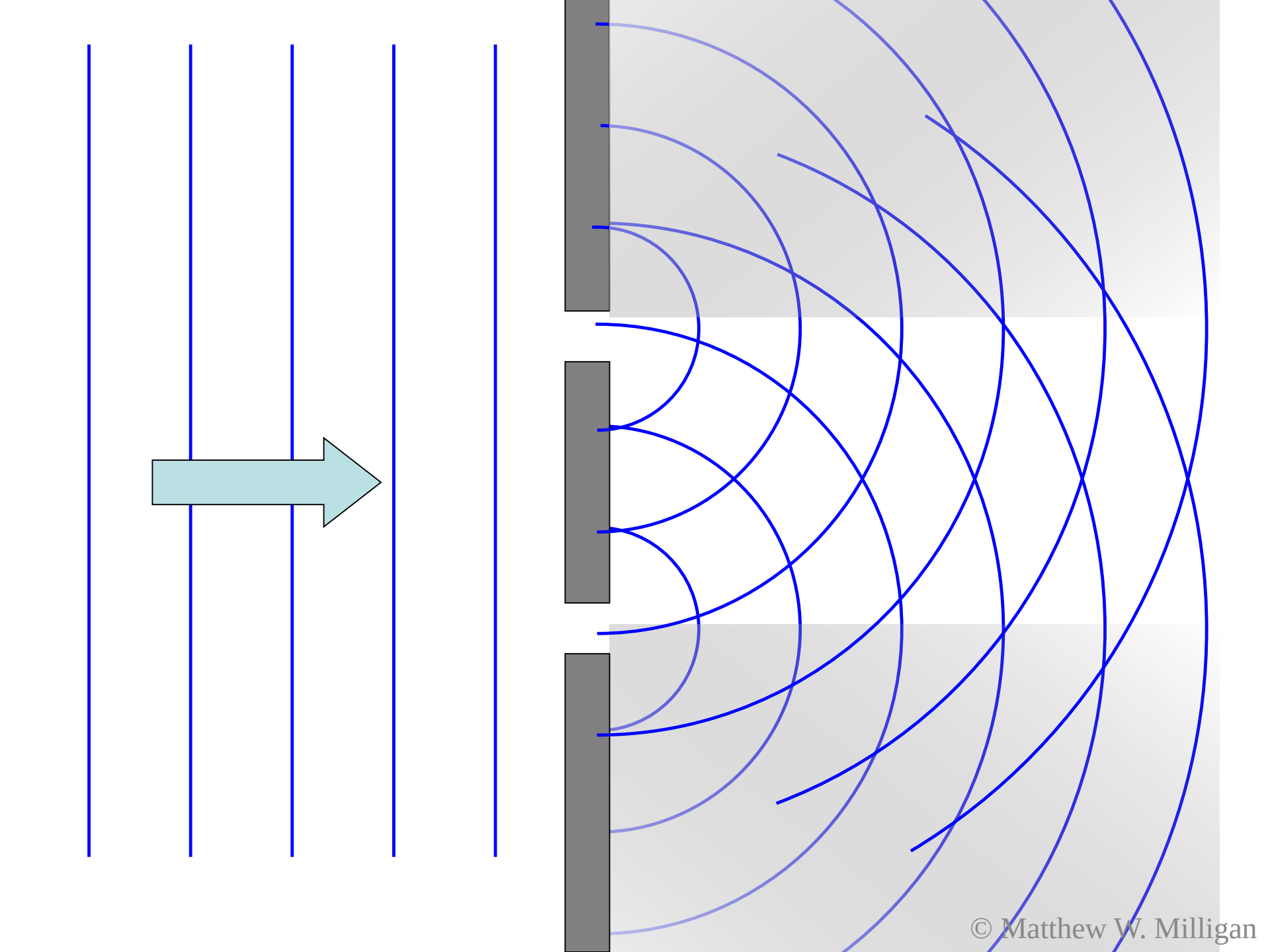


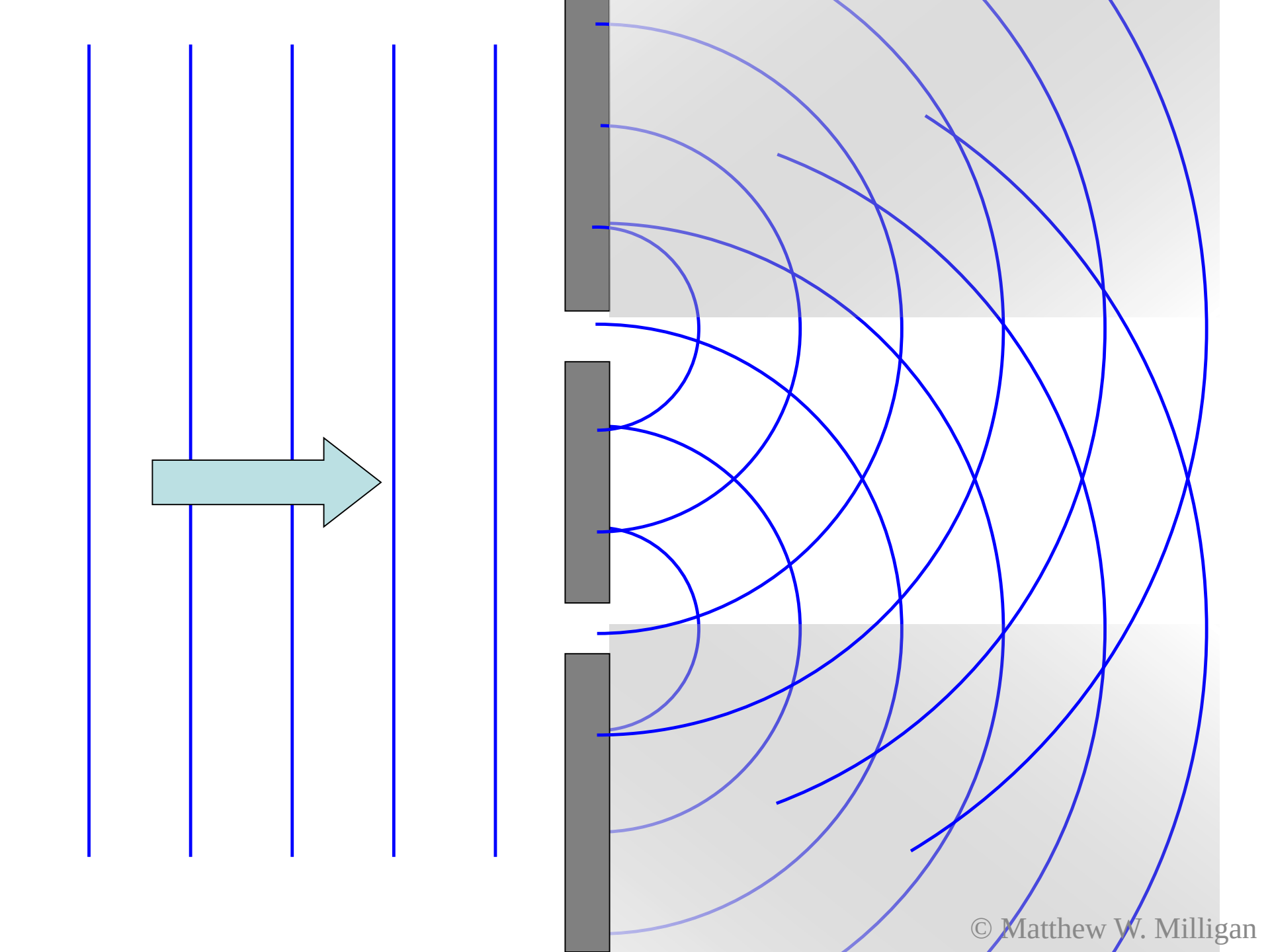
diffraction is less prominent at shorter wavelengths

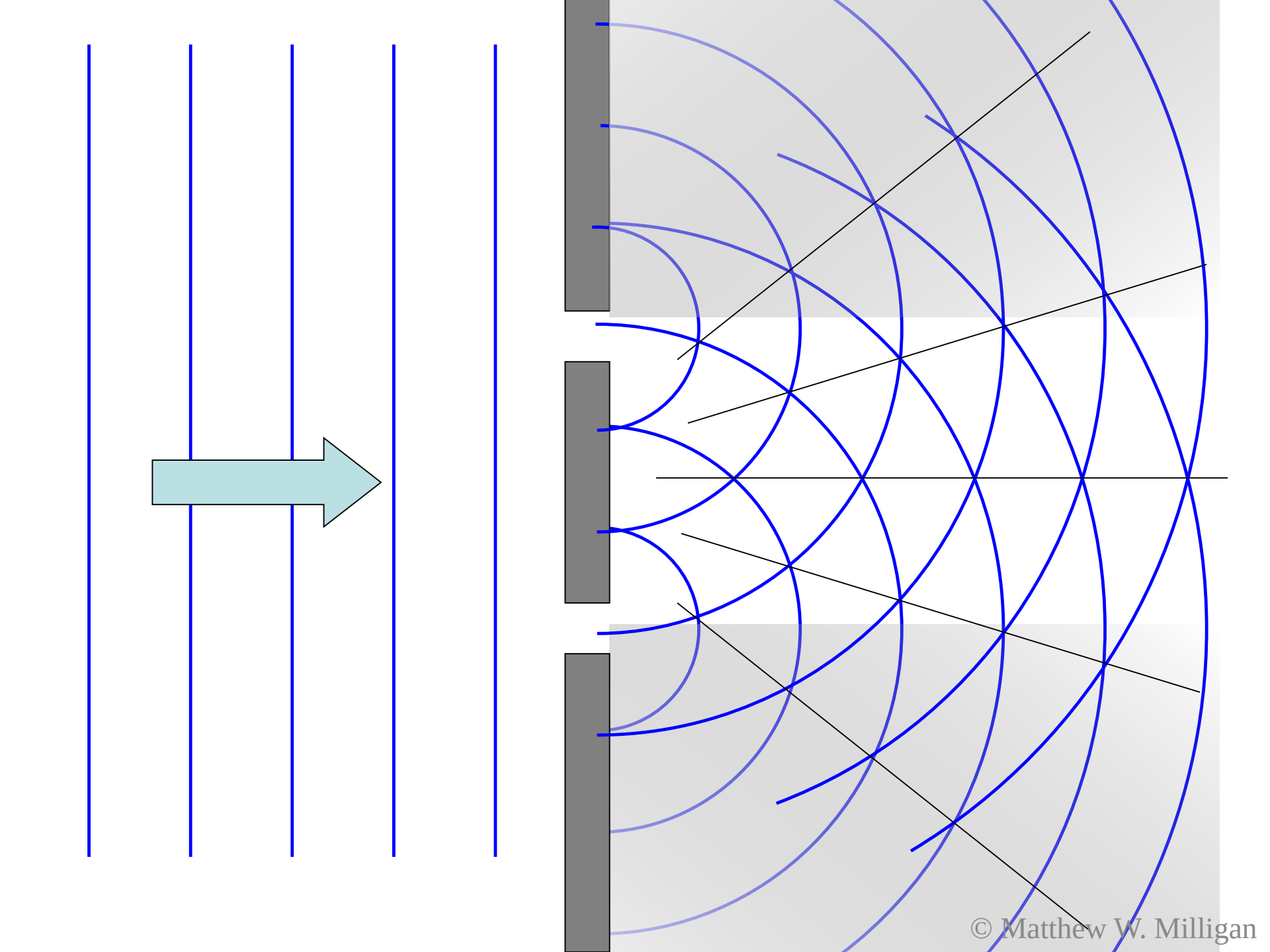


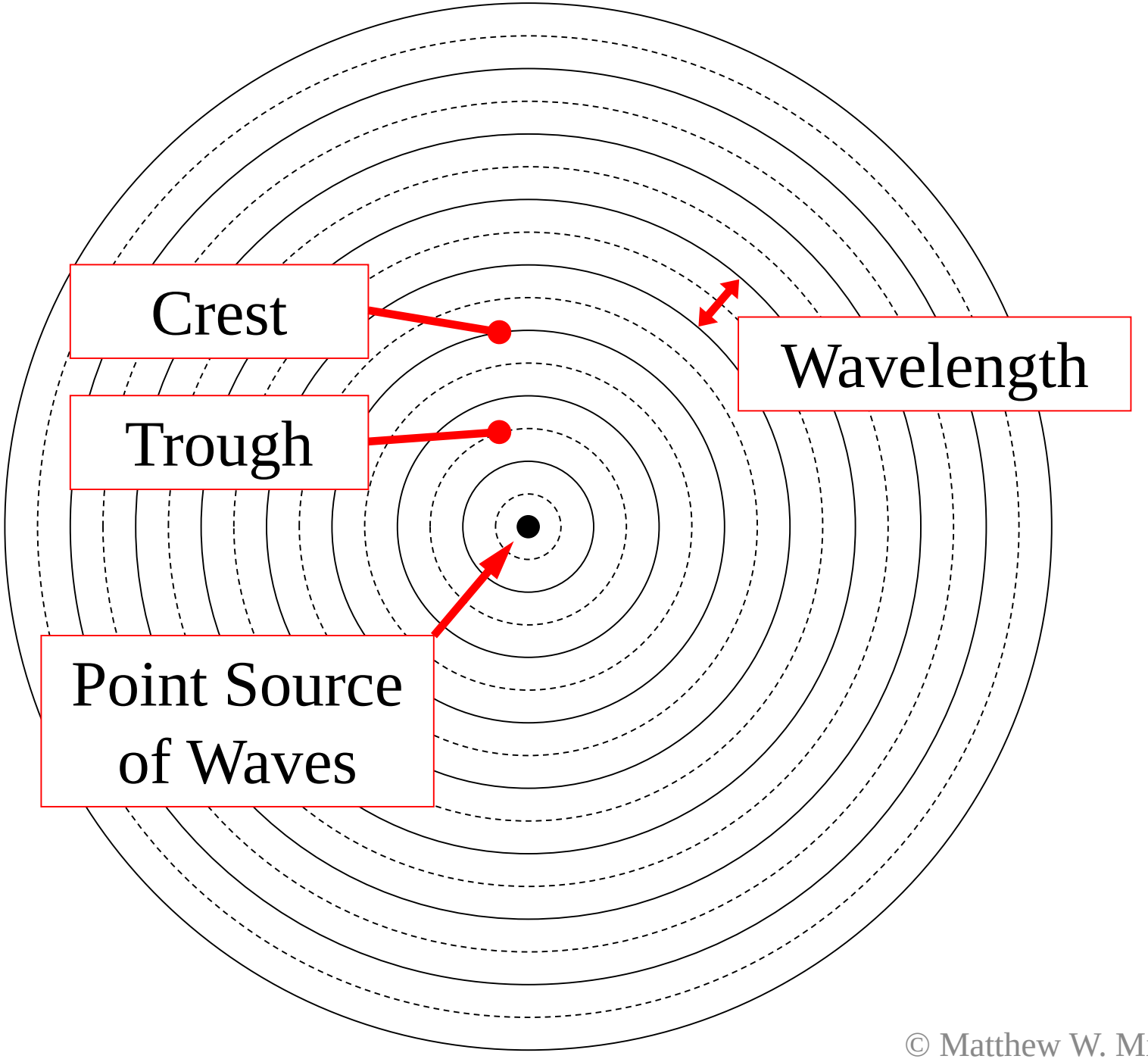
?

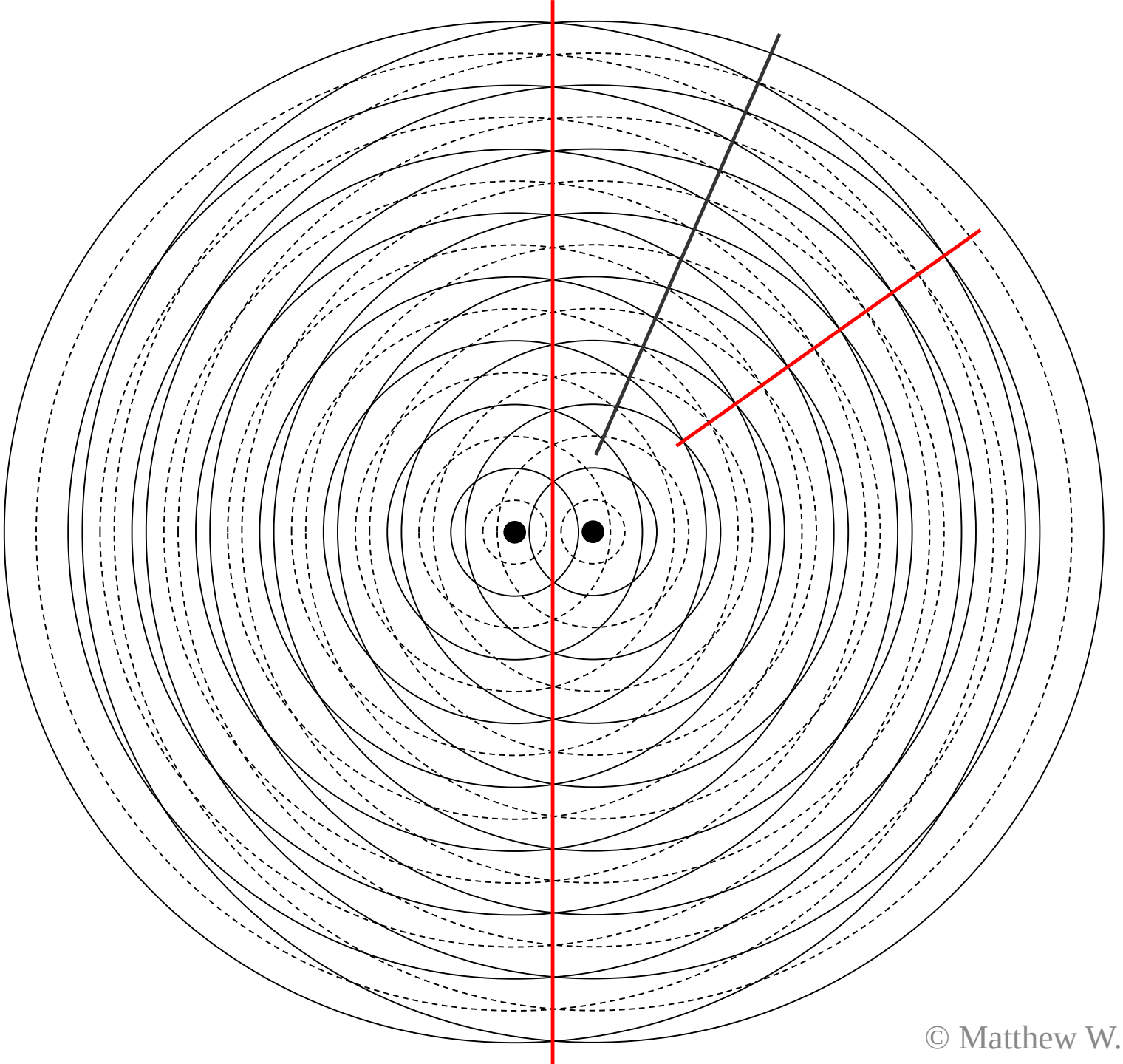


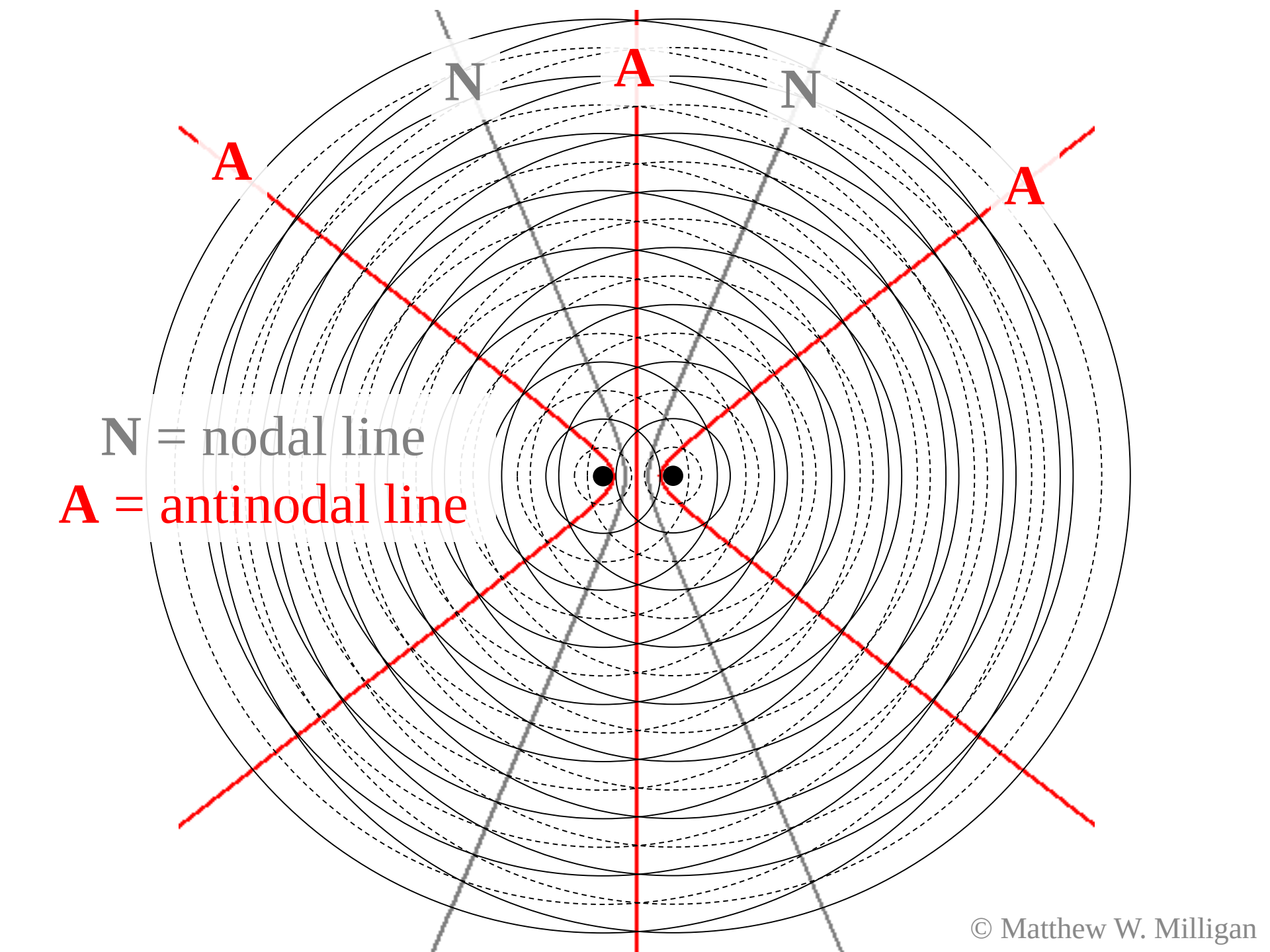


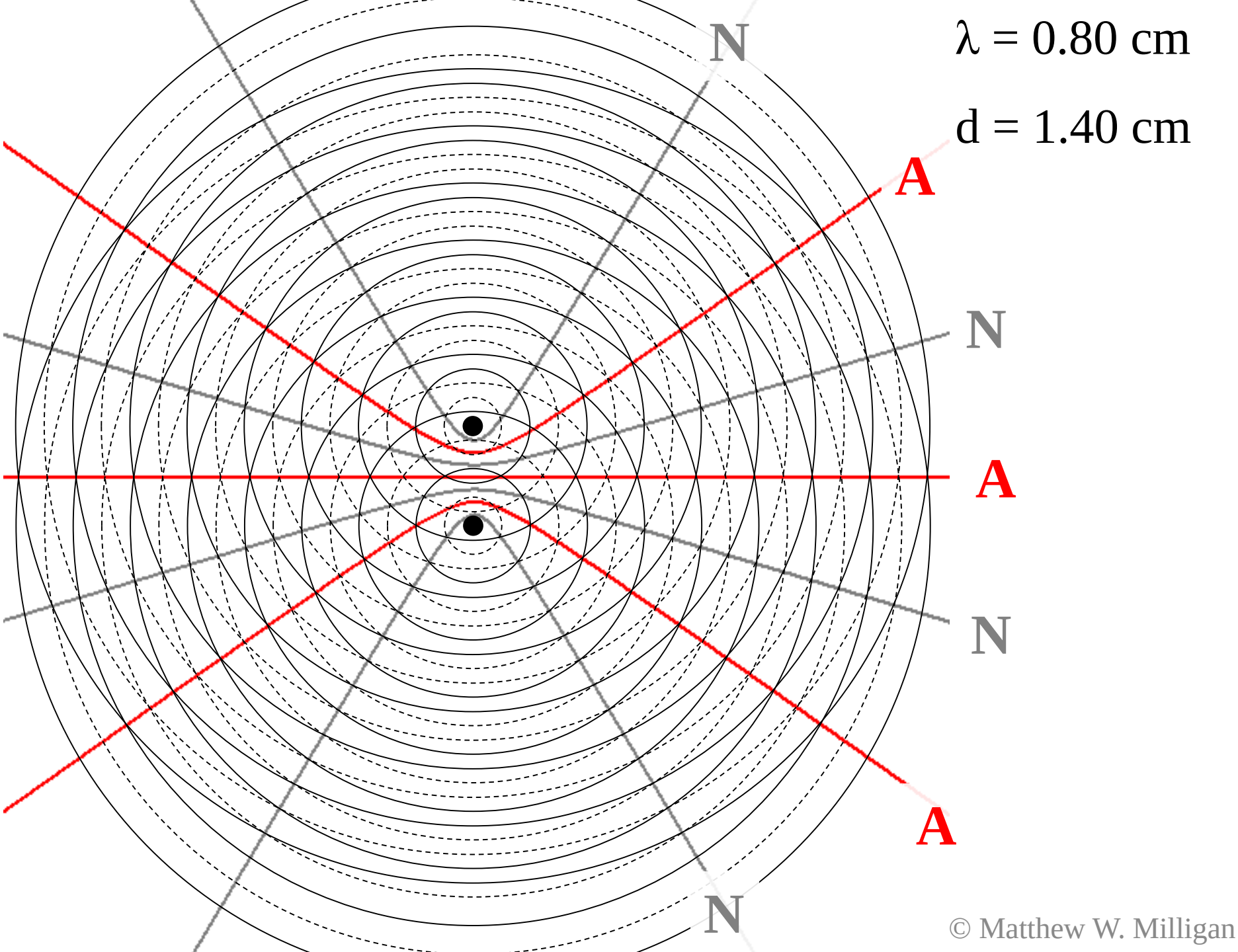


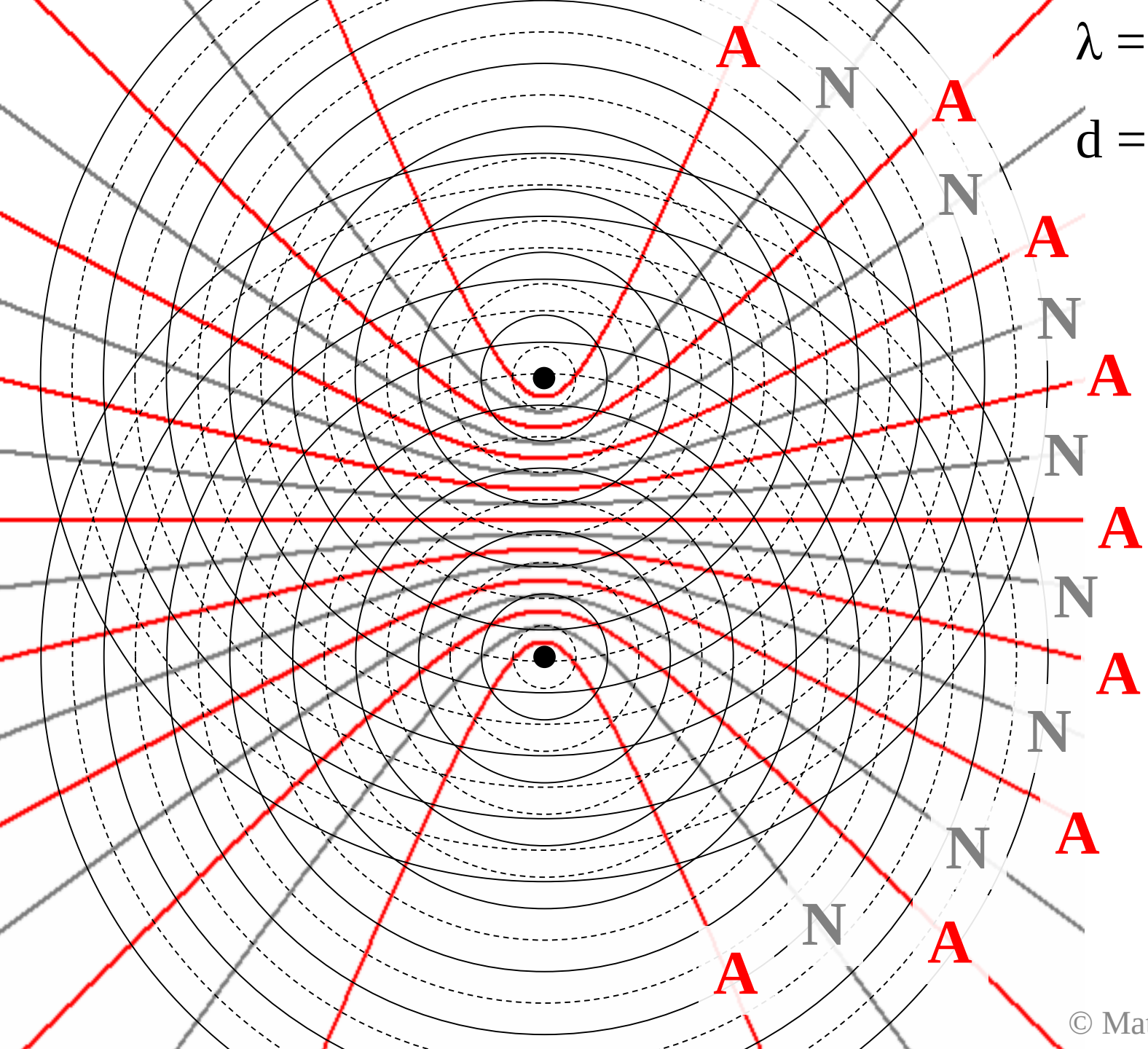






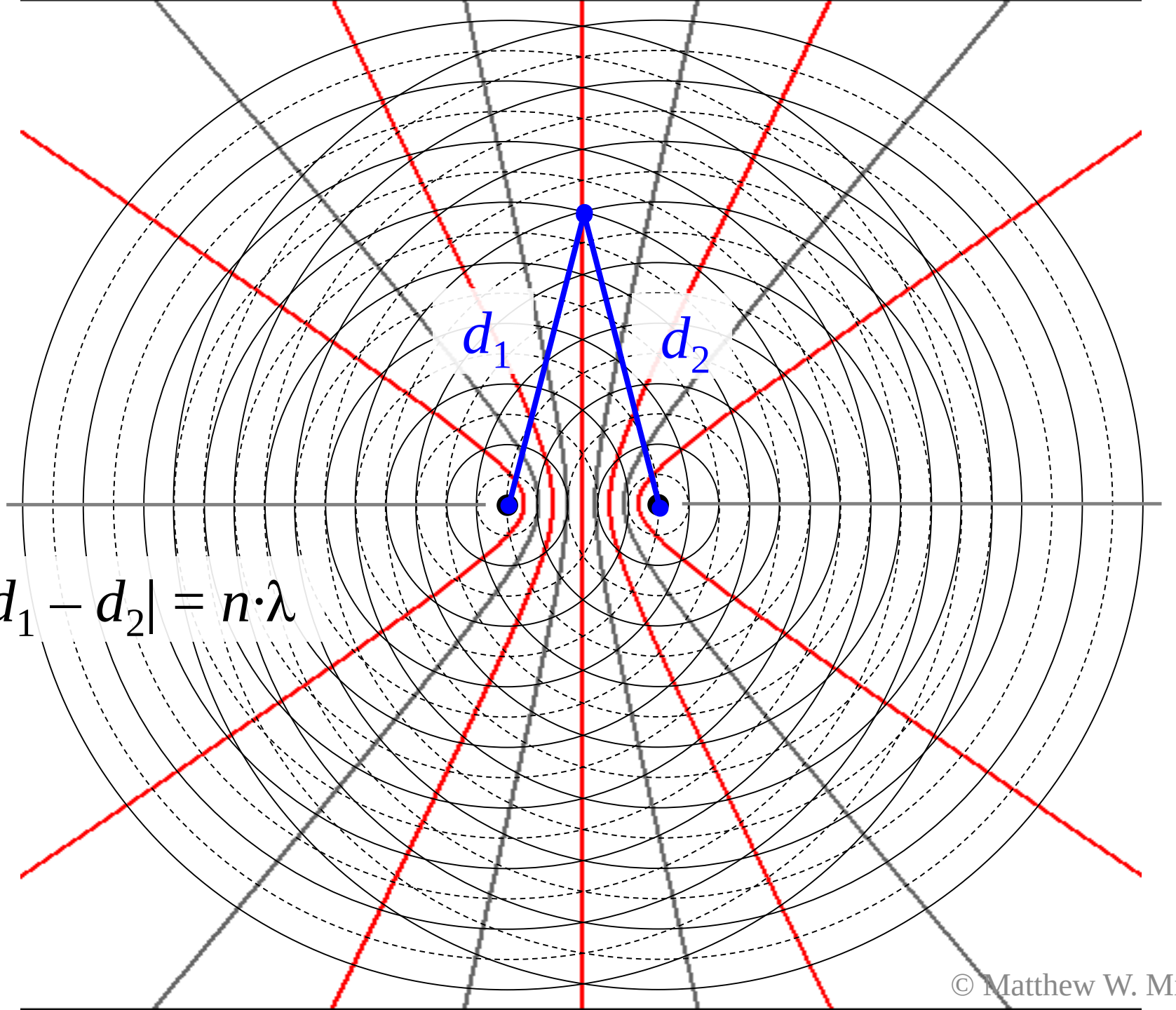


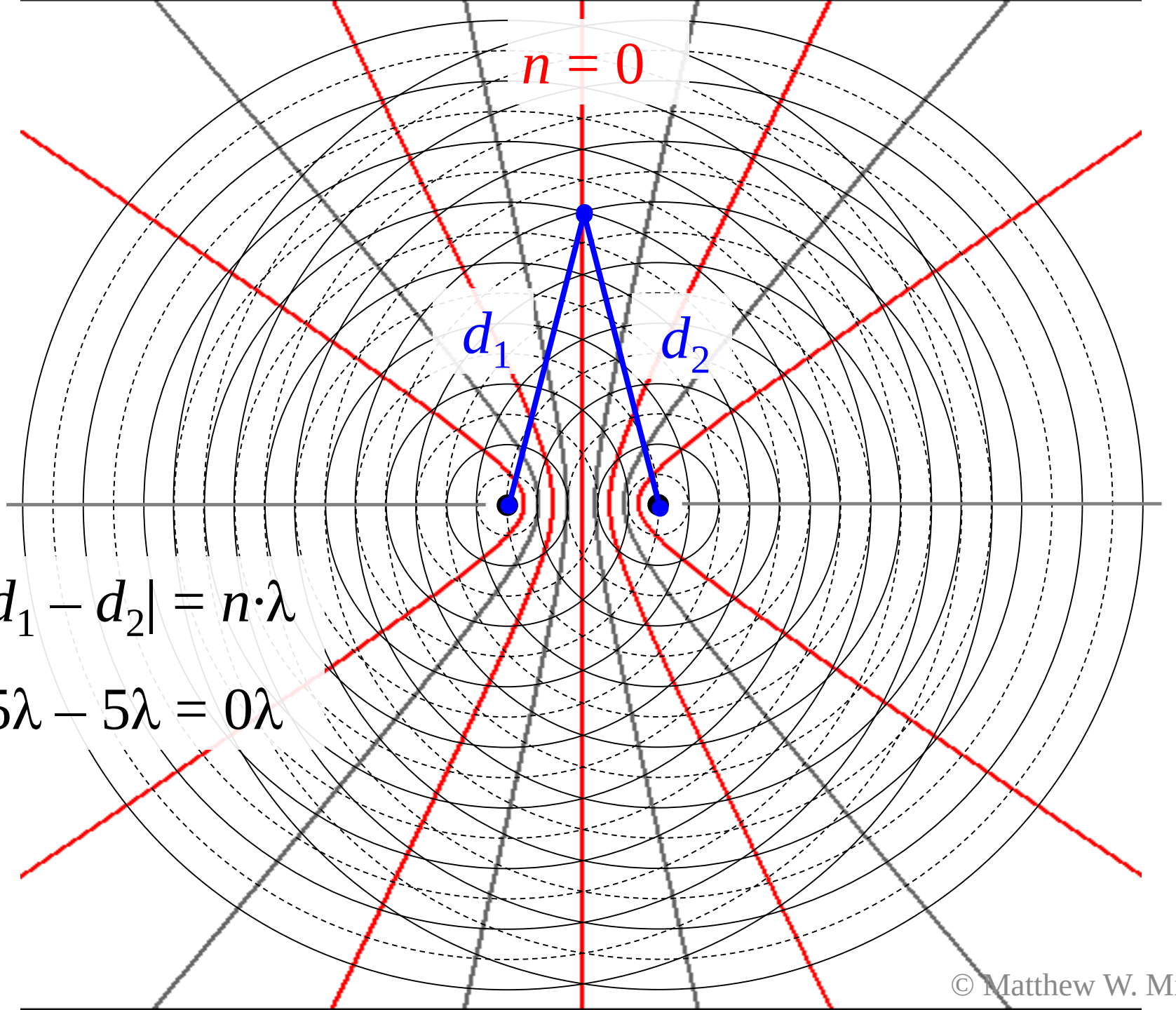




$\lambda = 0.80$ cm

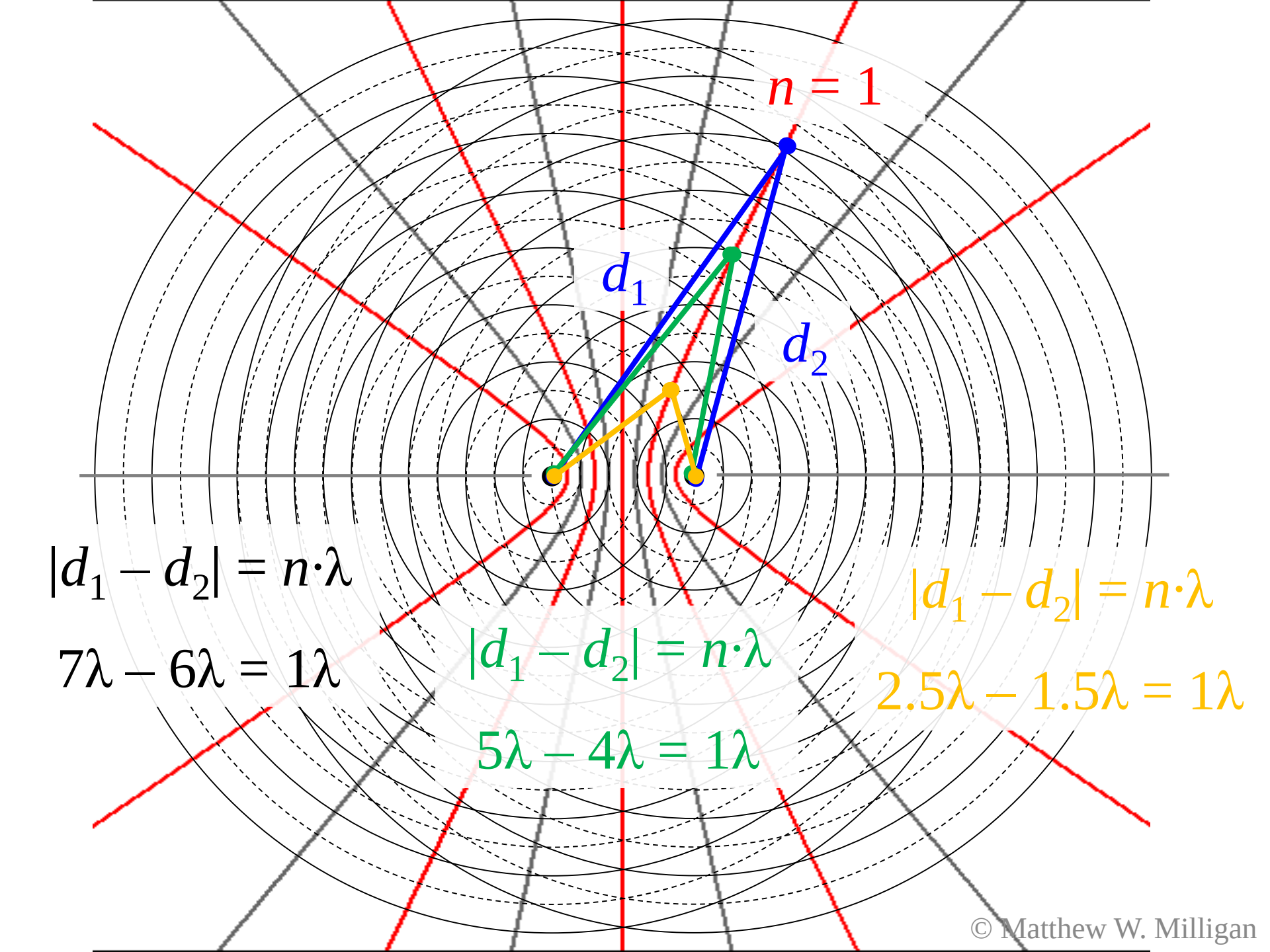
$d = 3.52$ cm

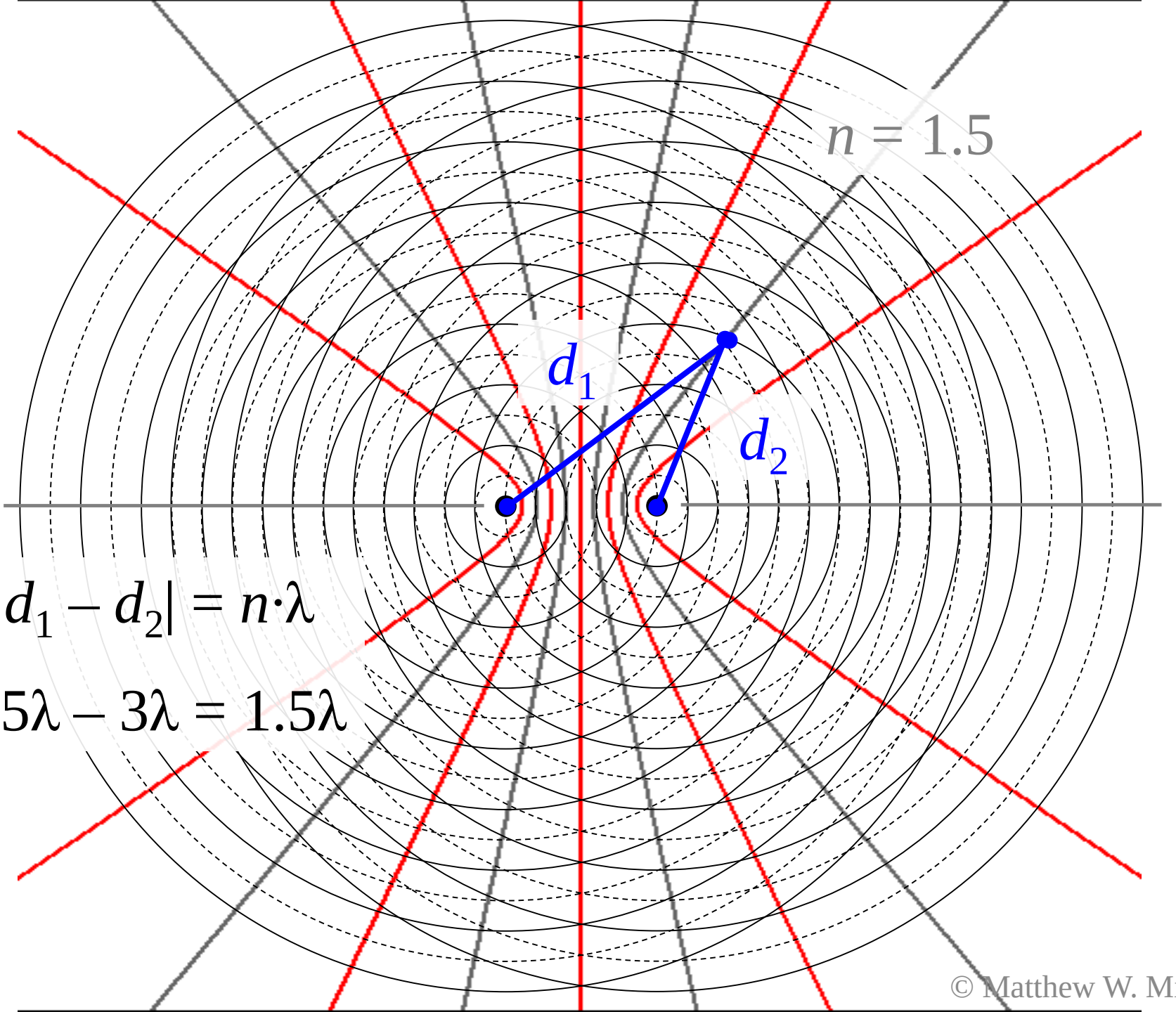




$$|d_1 - d_2| = n \cdot \lambda$$

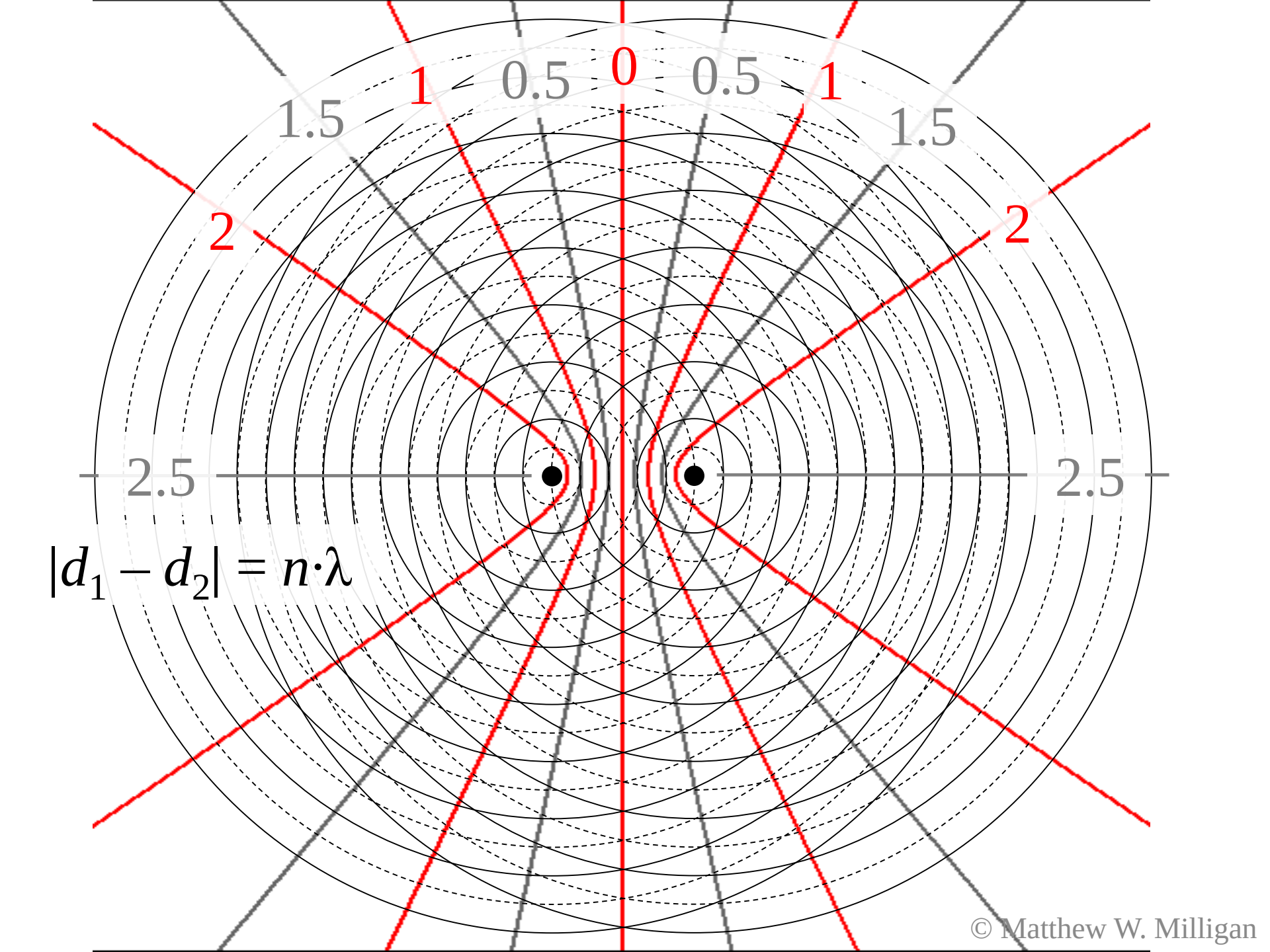
$$5\lambda - 5\lambda = 0\lambda$$





$$|d_1 - d_2| = n \cdot \lambda$$

$$4.5\lambda - 3\lambda = 1.5\lambda$$



Path Difference vs. Interference

Assuming two wave sources act in phase the type of resulting interference relates to different distances travelled by waves:

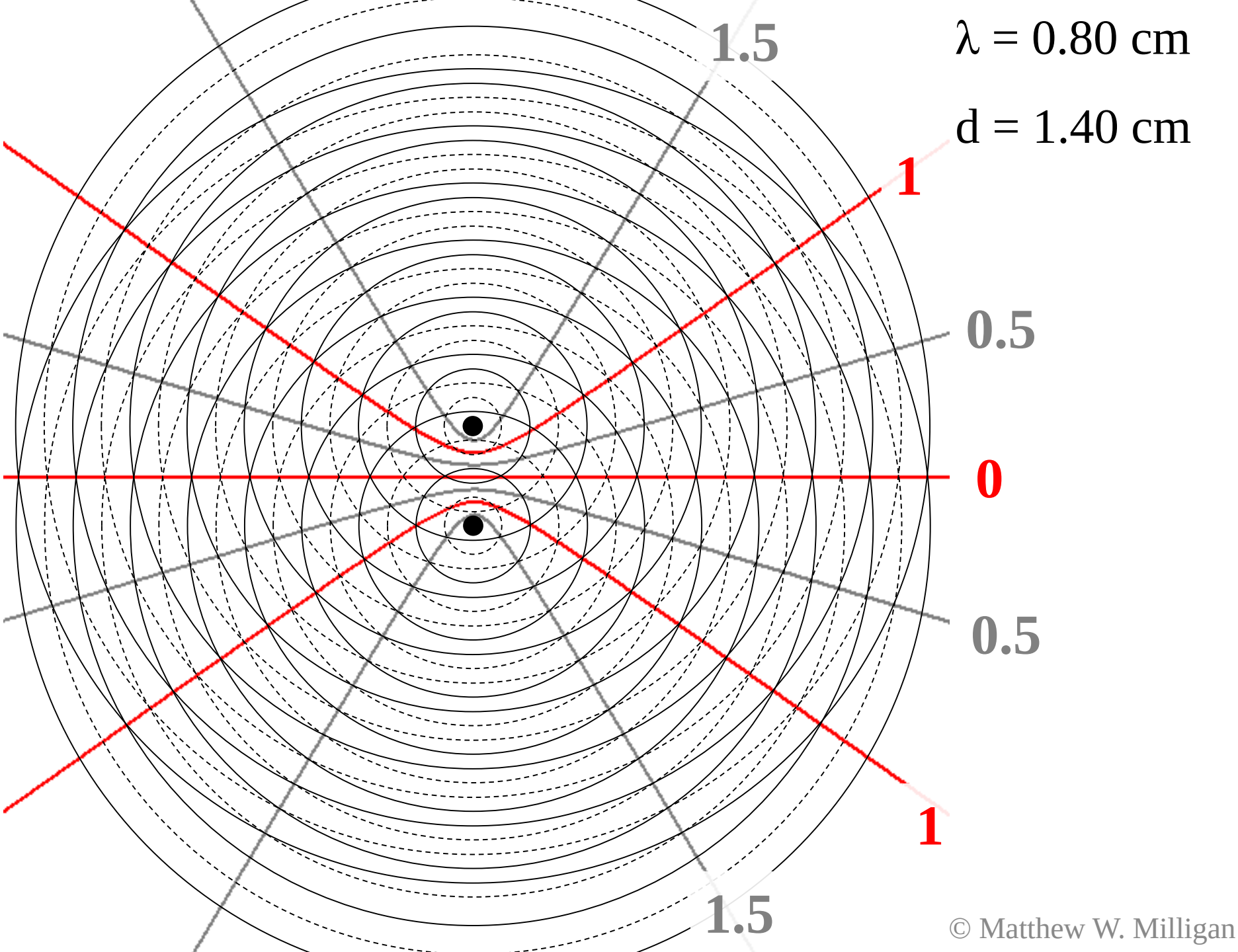
$$|d_1 - d_2| = n \cdot \lambda$$

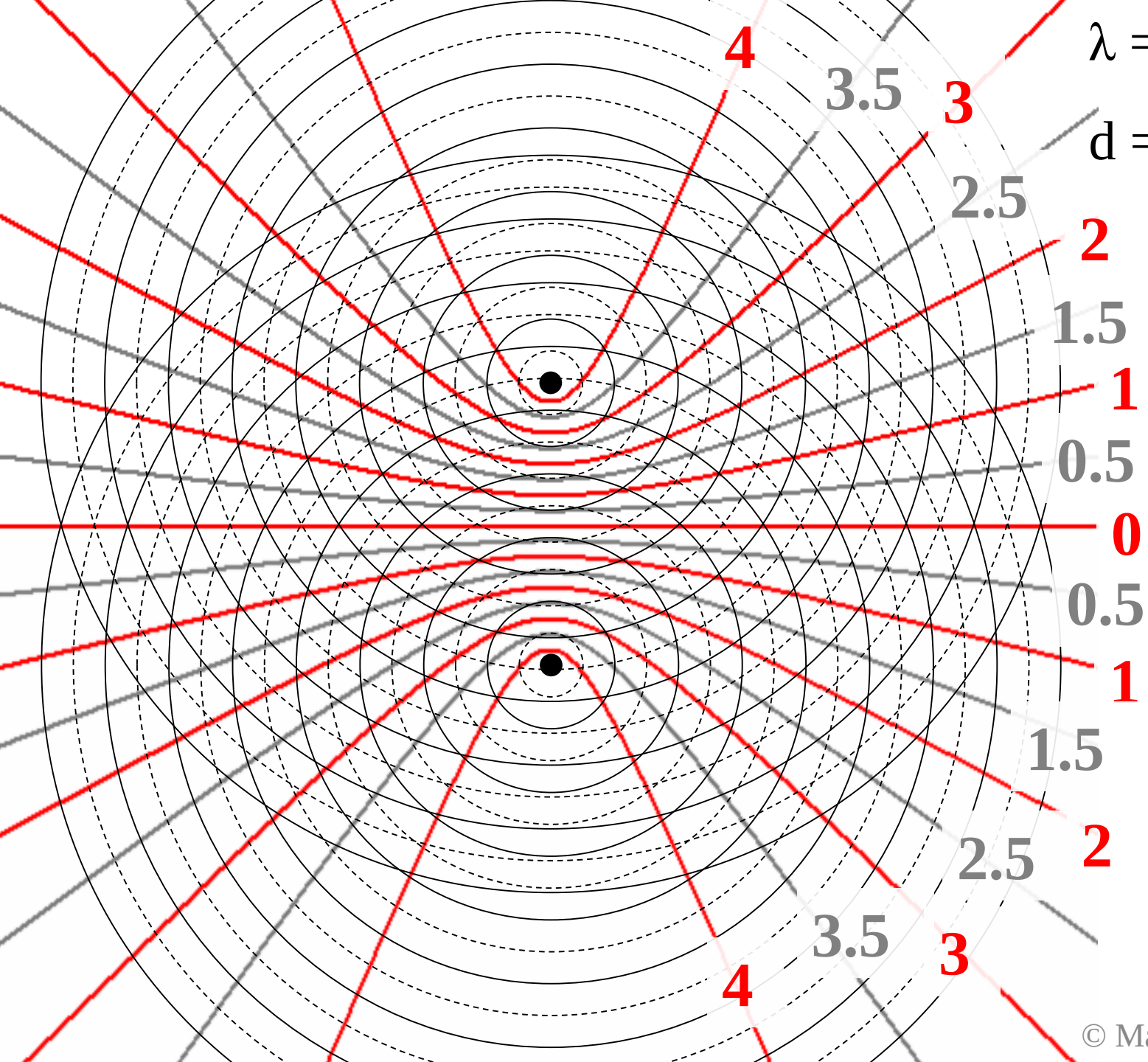
where: d_1 = distance to one source

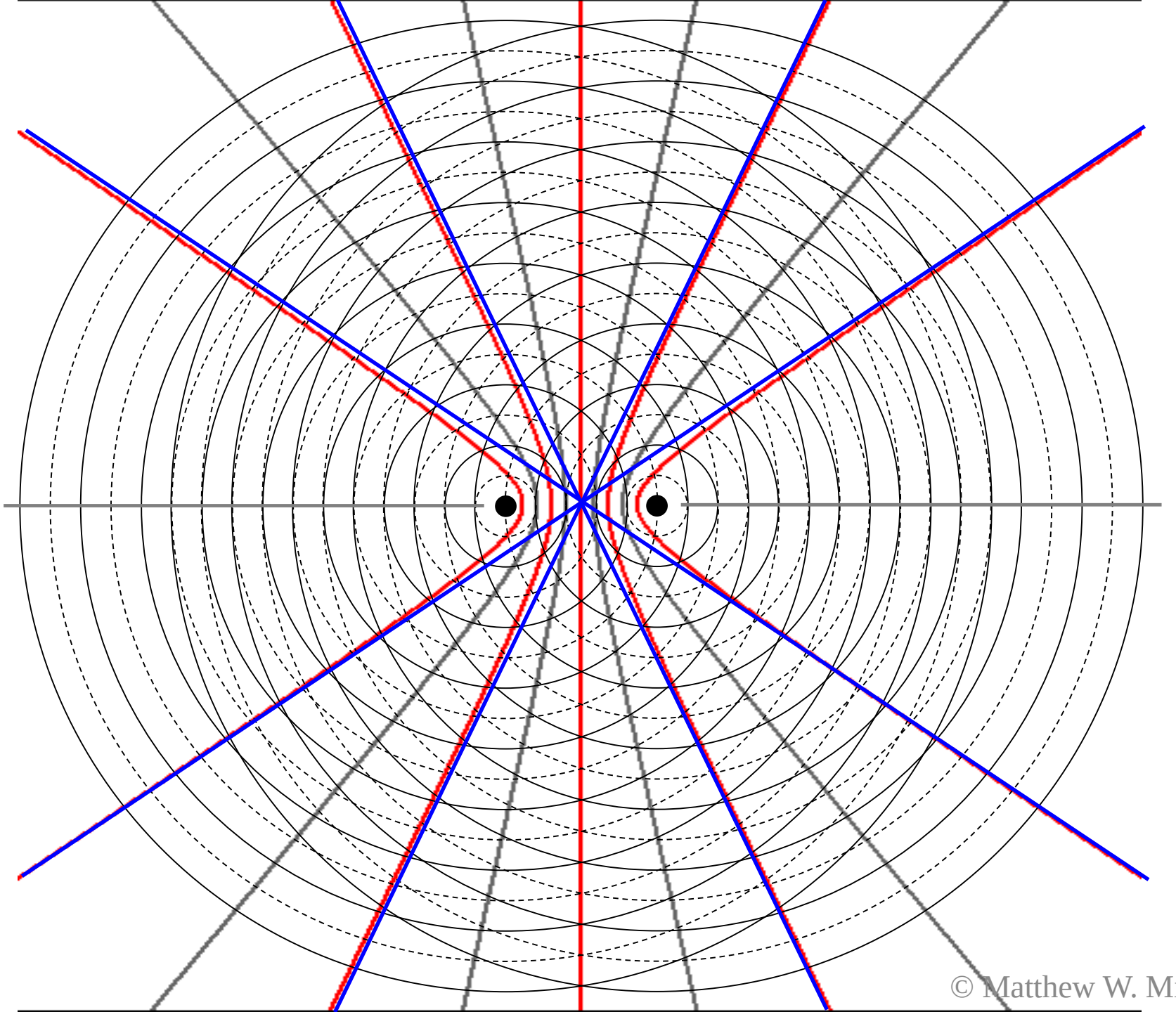
d_2 = distance to other source

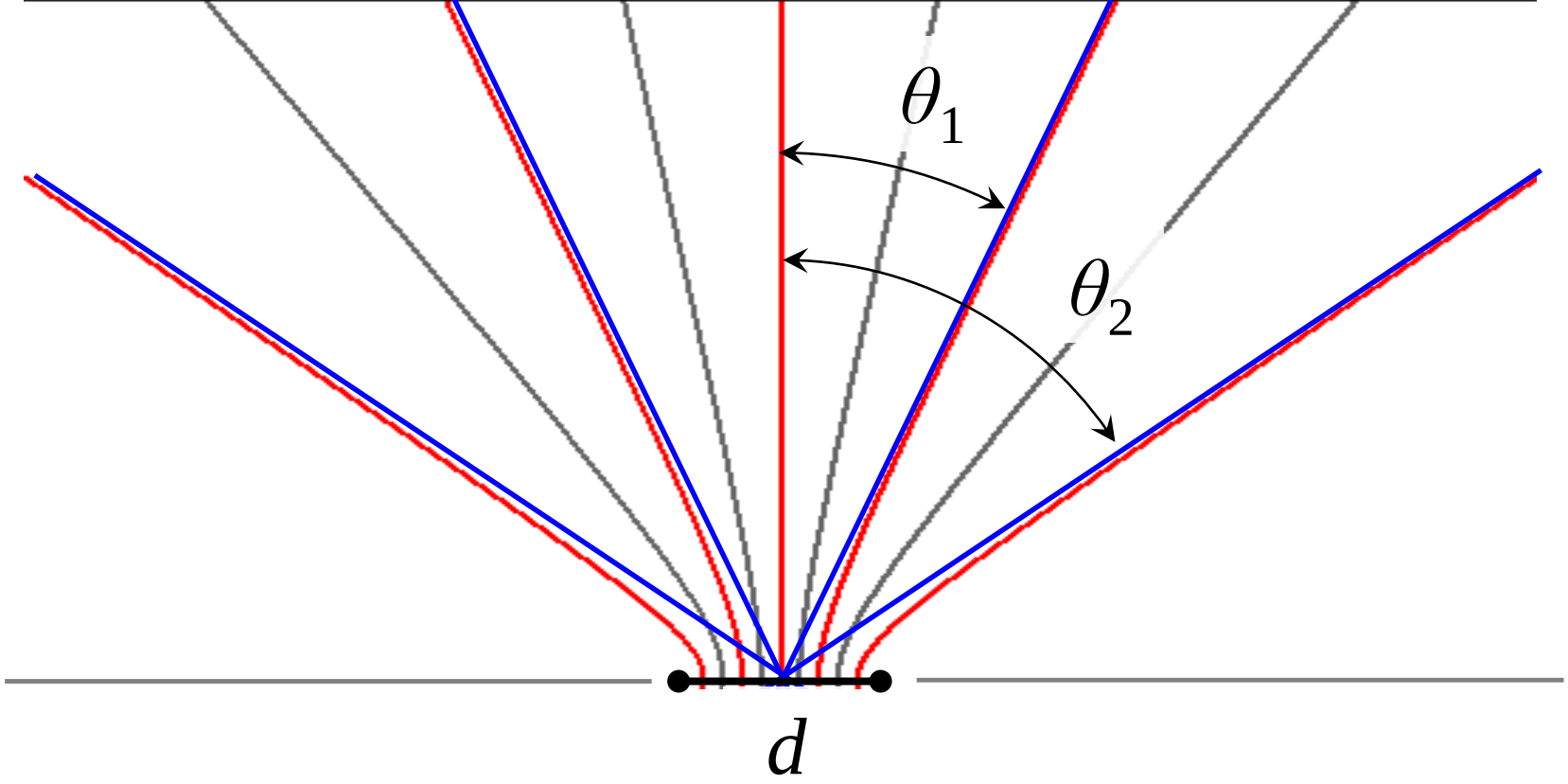
$n = 0, 1, 2, 3 \ldots$ (constr. interf.)

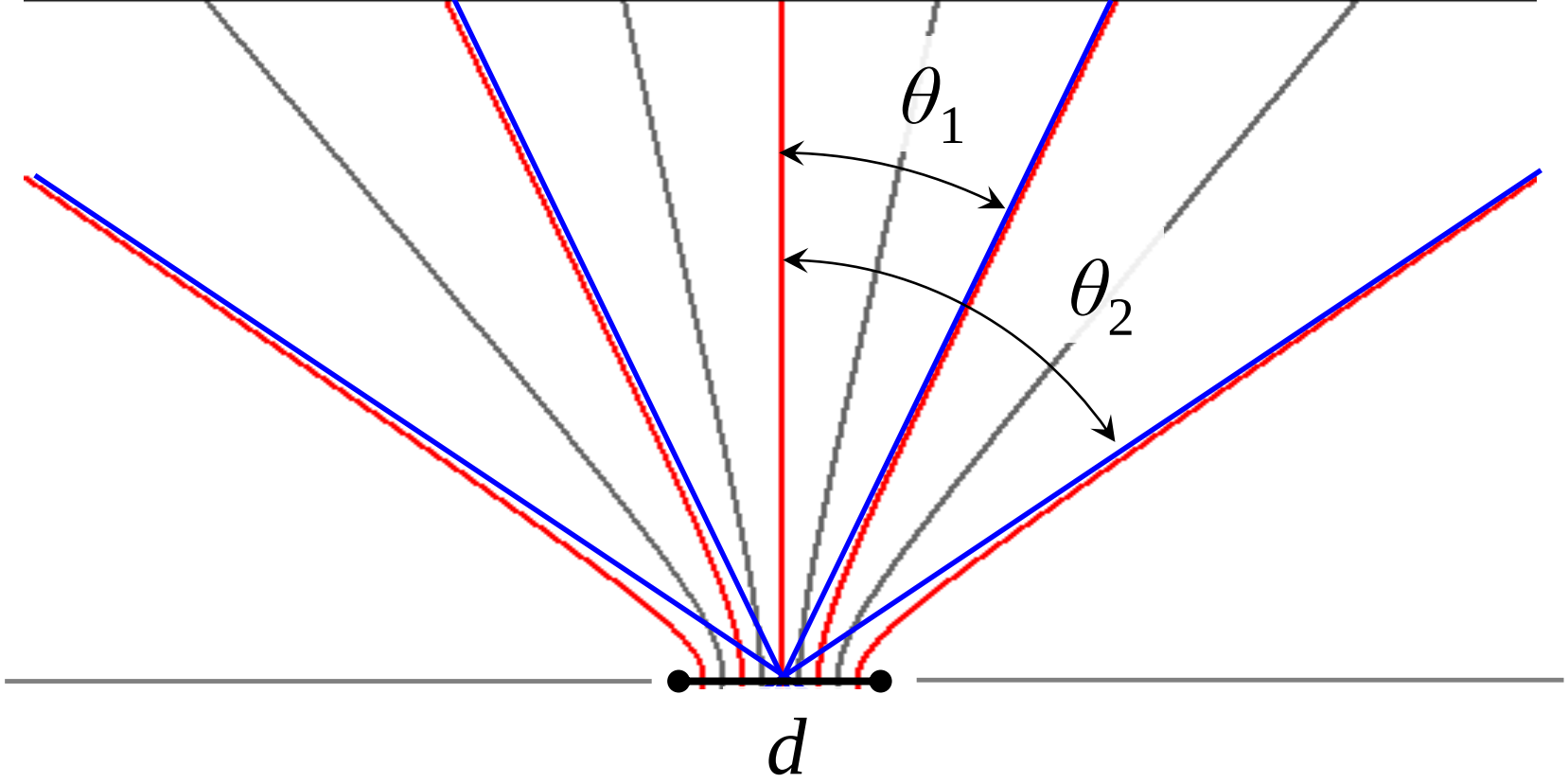
$n = 0.5, 1.5, 2.5 \ldots$ (destr. interf.)



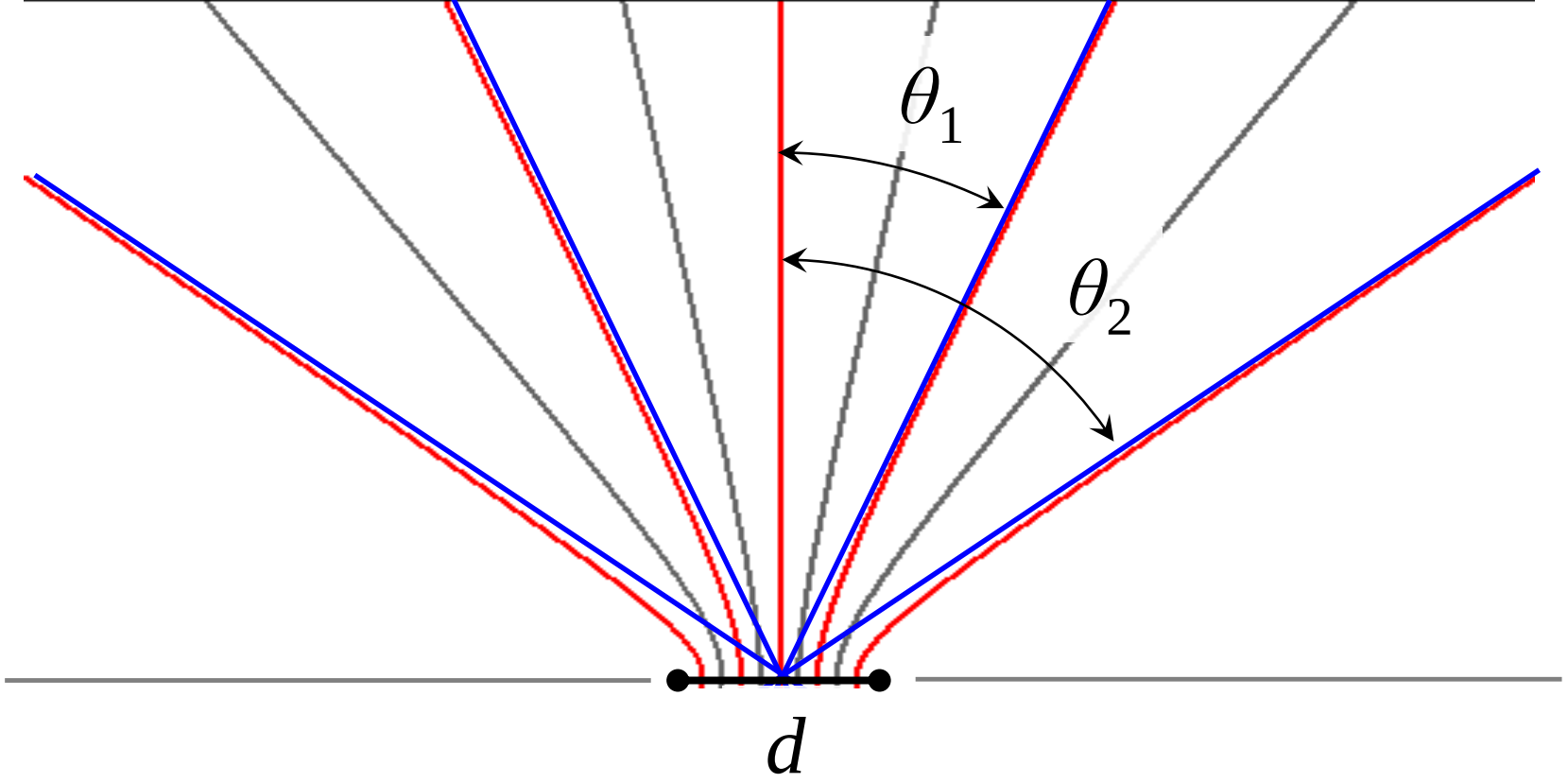








$$\sin\theta_n = \frac{n\lambda}{d}$$

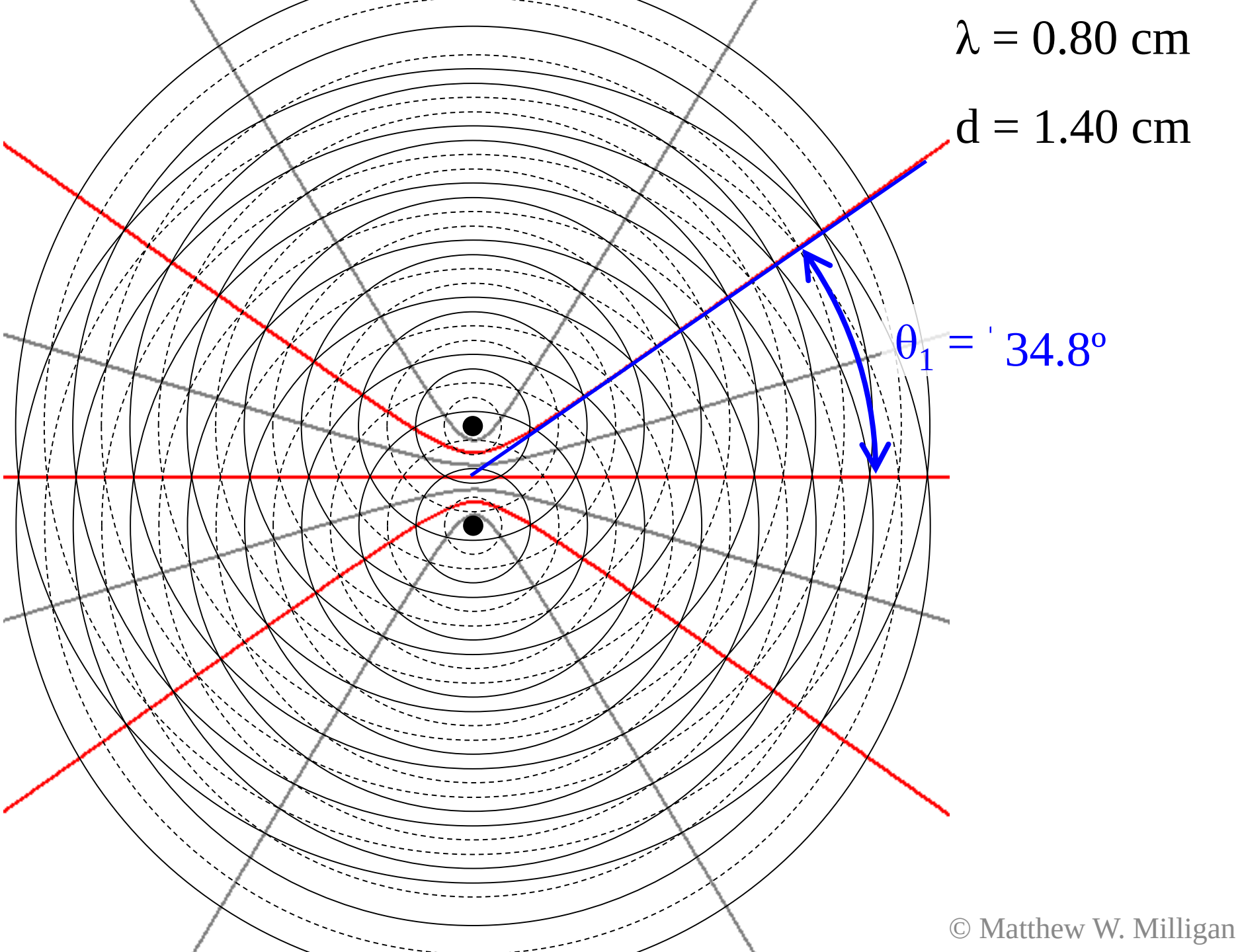


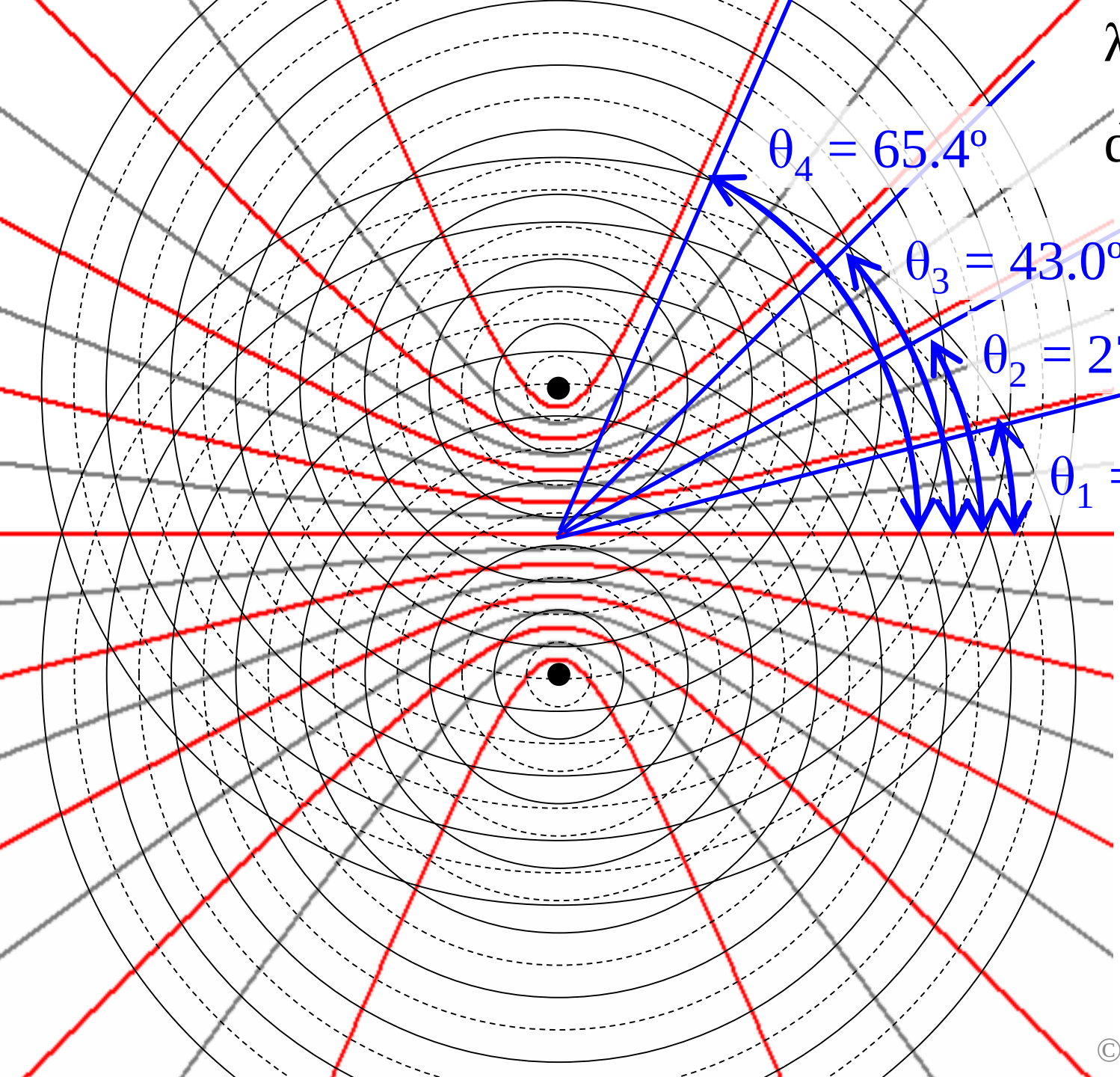
$$\sin\theta_n = \frac{n\lambda}{d}$$

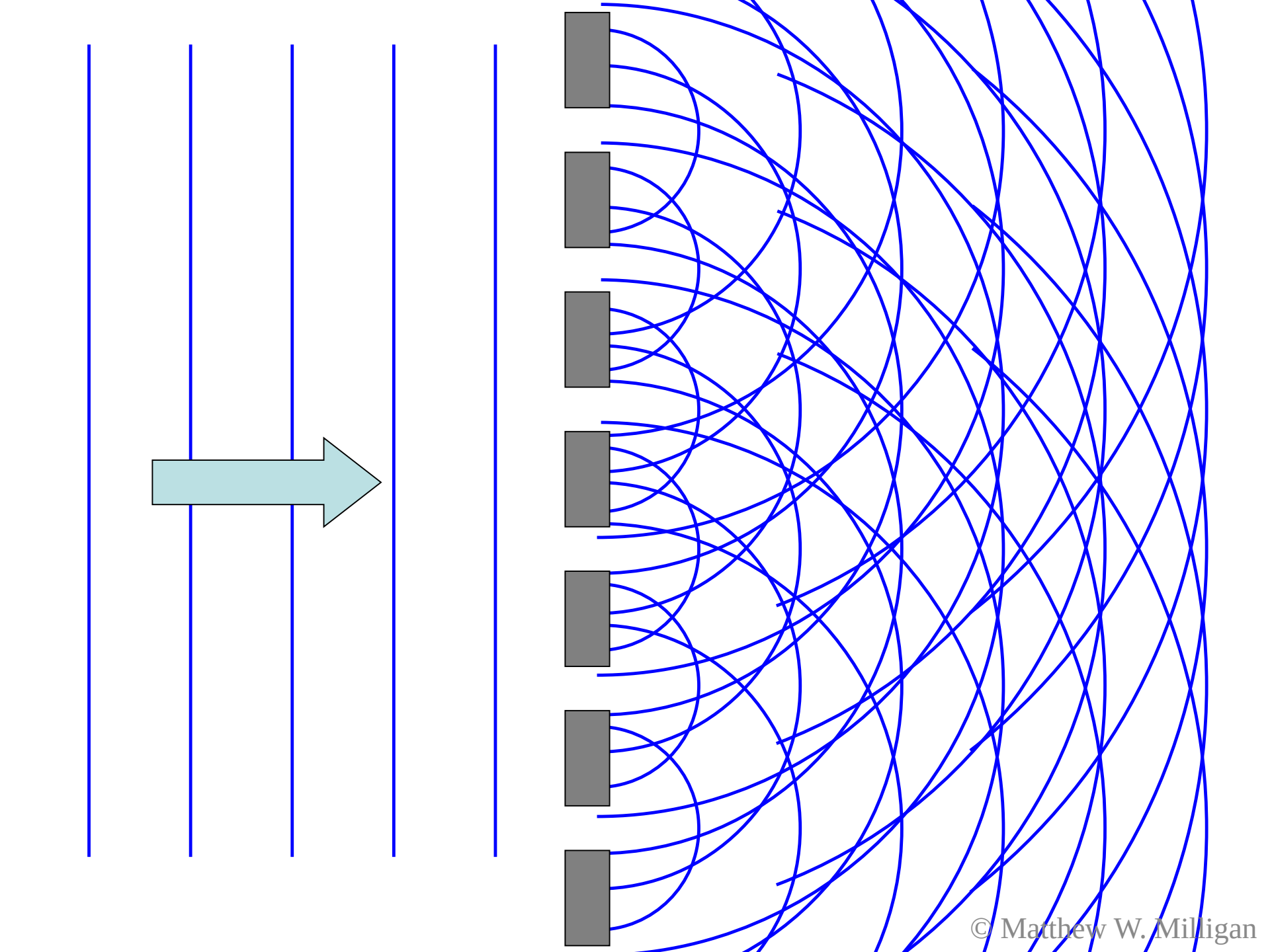
d = separation of sources

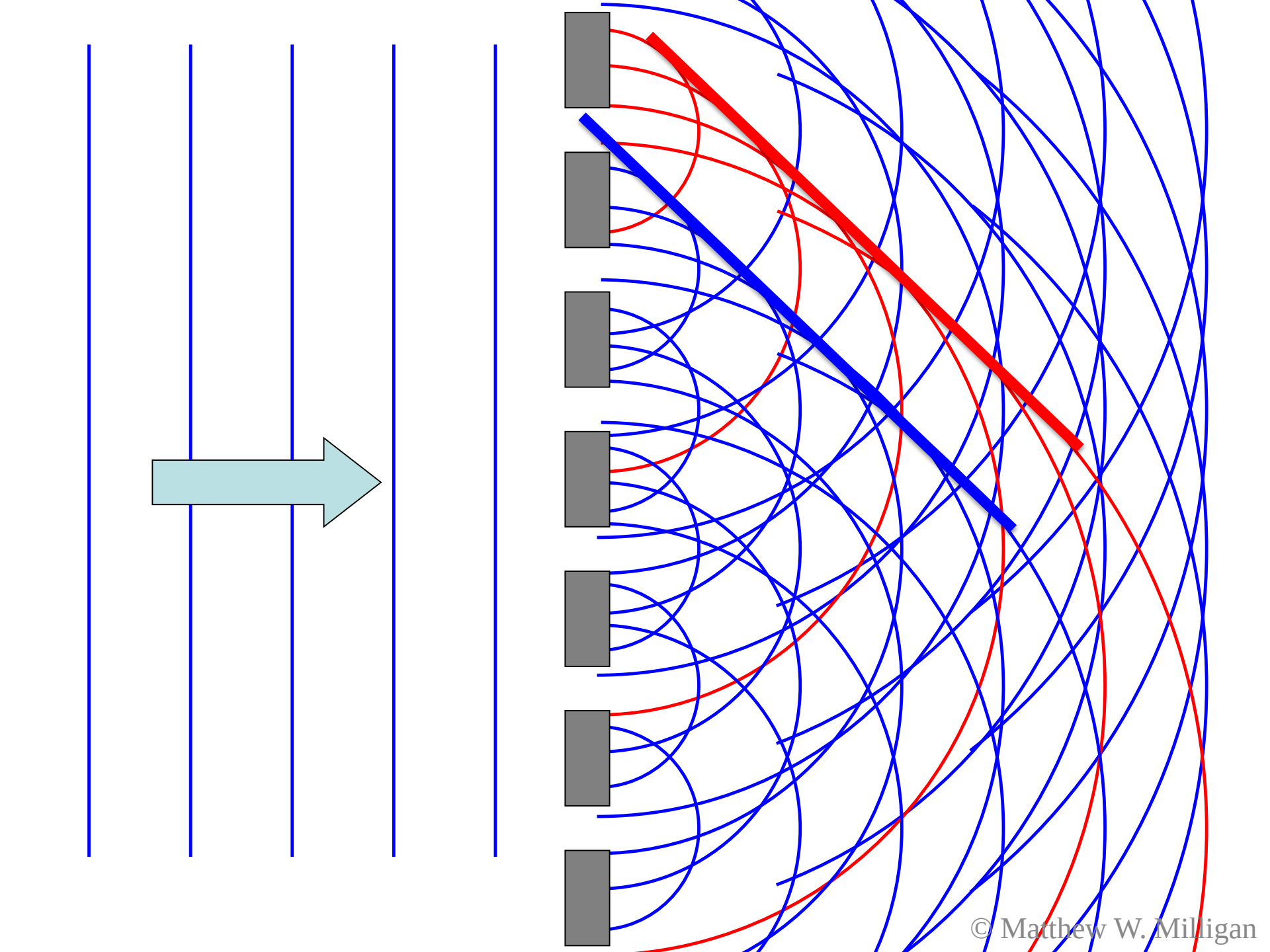
n = 1, 2, 3 … (constr. interf.)

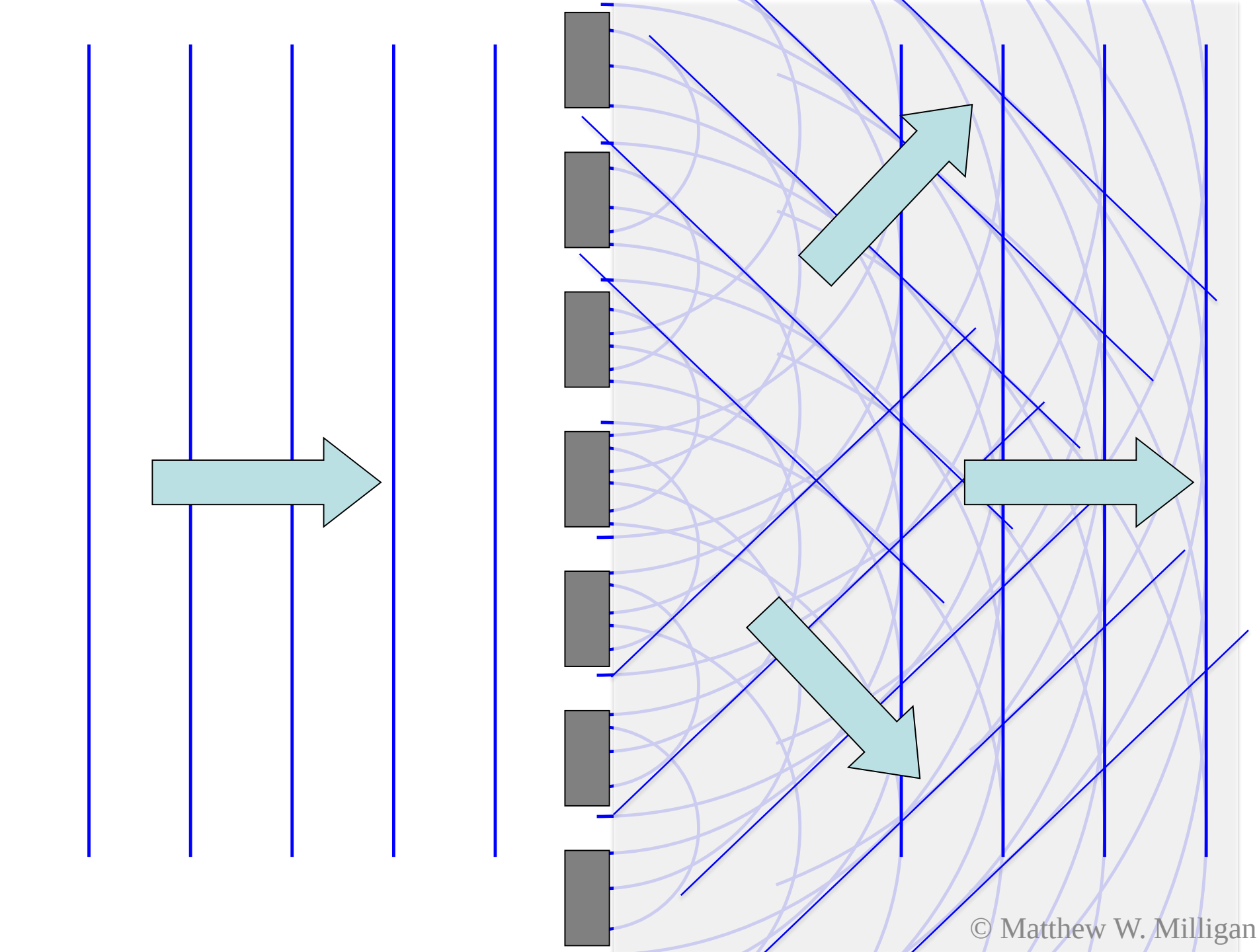
n = 0.5, 1.5 … (destr. interf.)

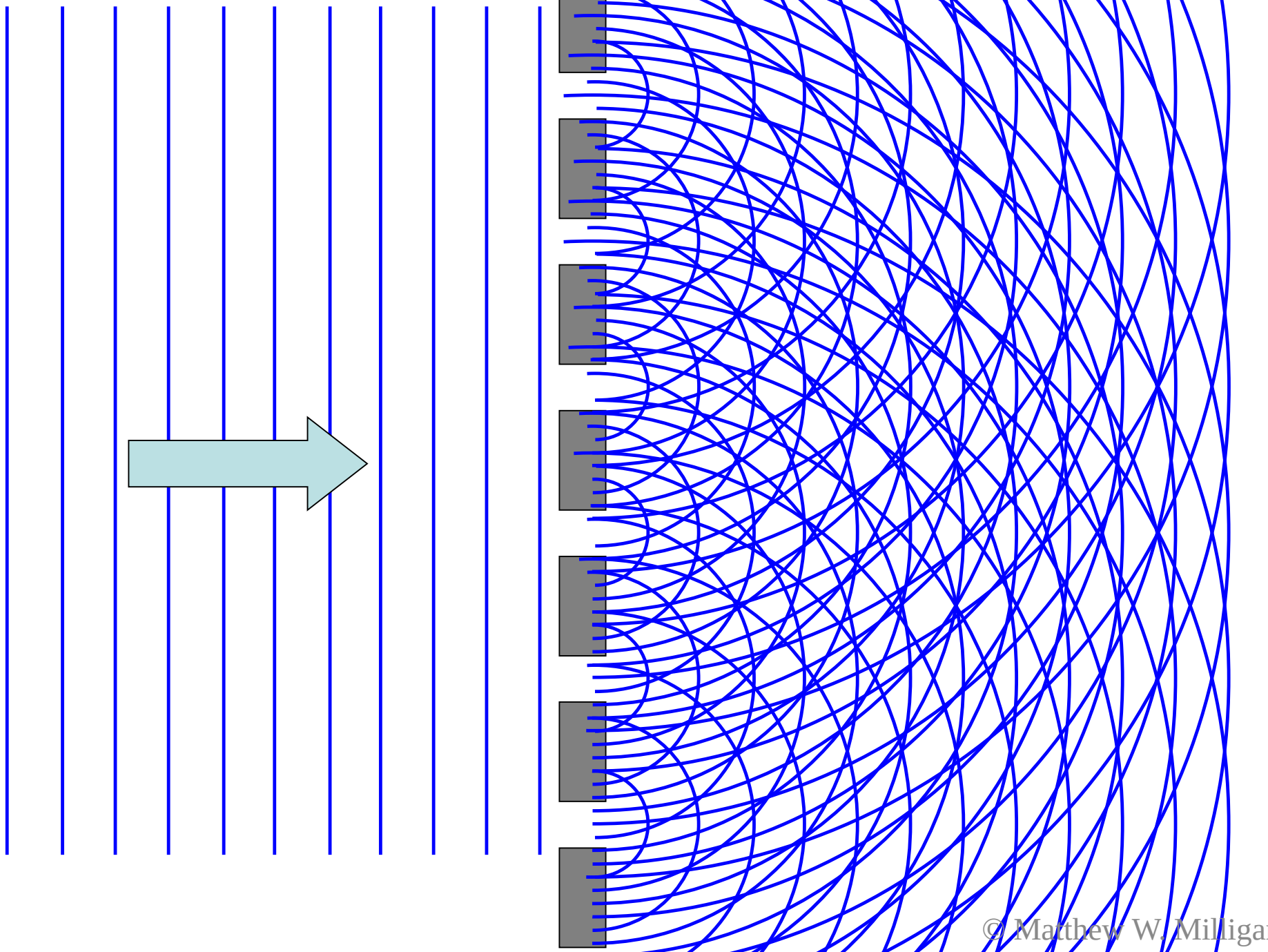


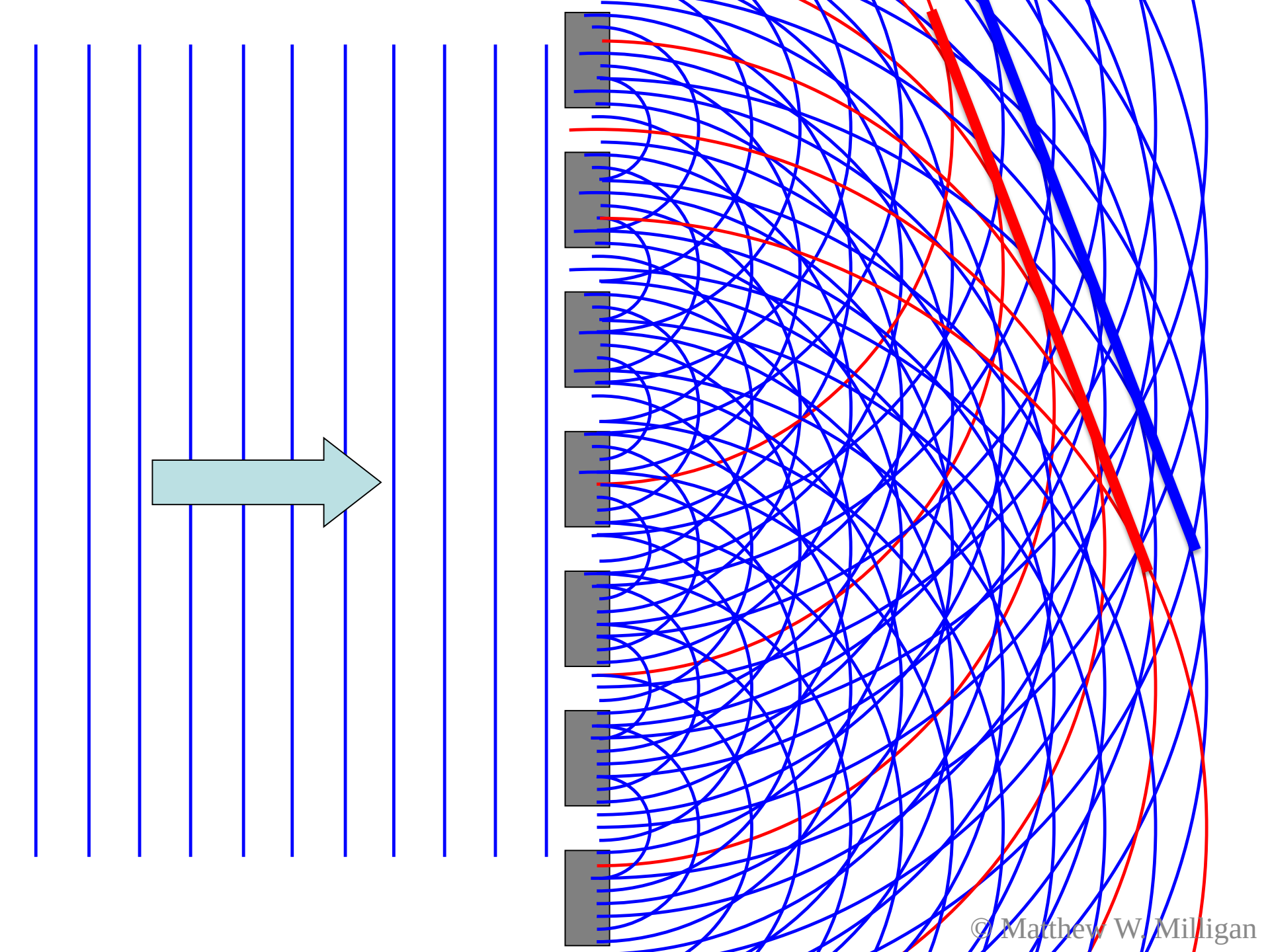











© Matthew W. Milligan