Signals and Systems
An Introduction to Fourier Optics

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Course Number: 20 14 255

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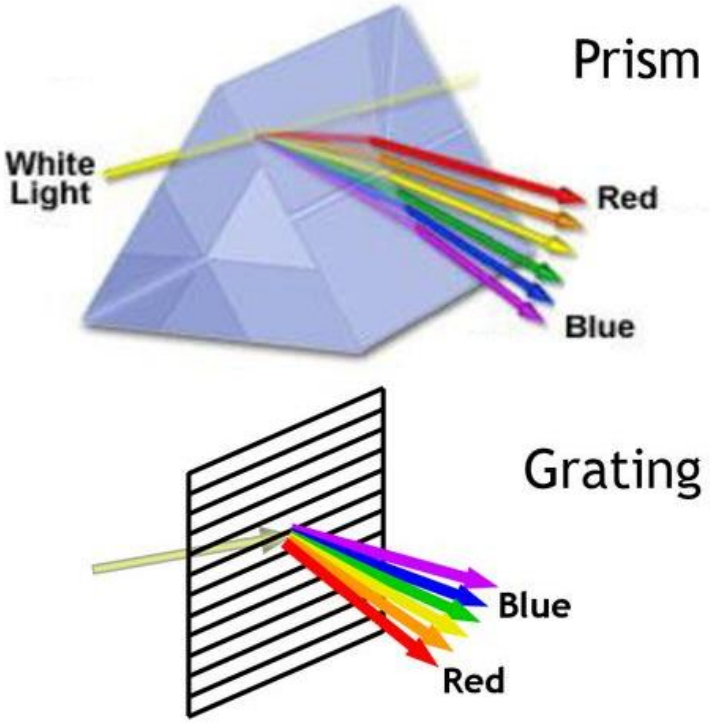
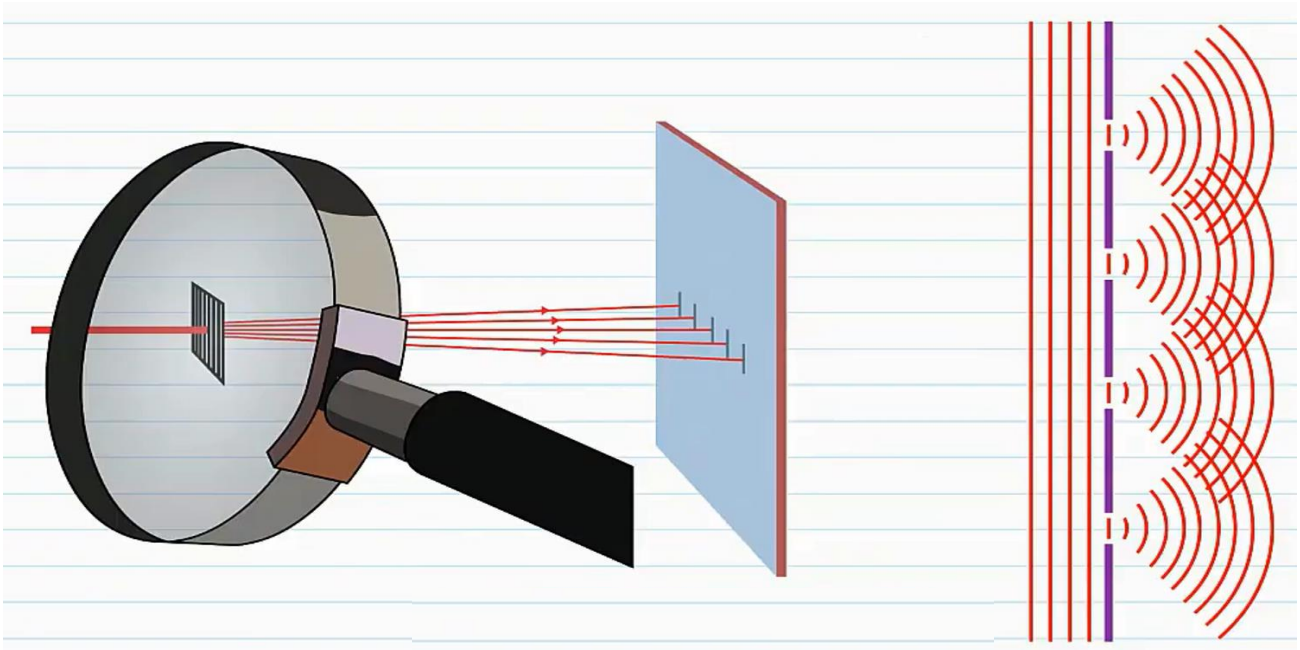
Optical Diffraction Grating

- Each color has a well-defined wavelength.



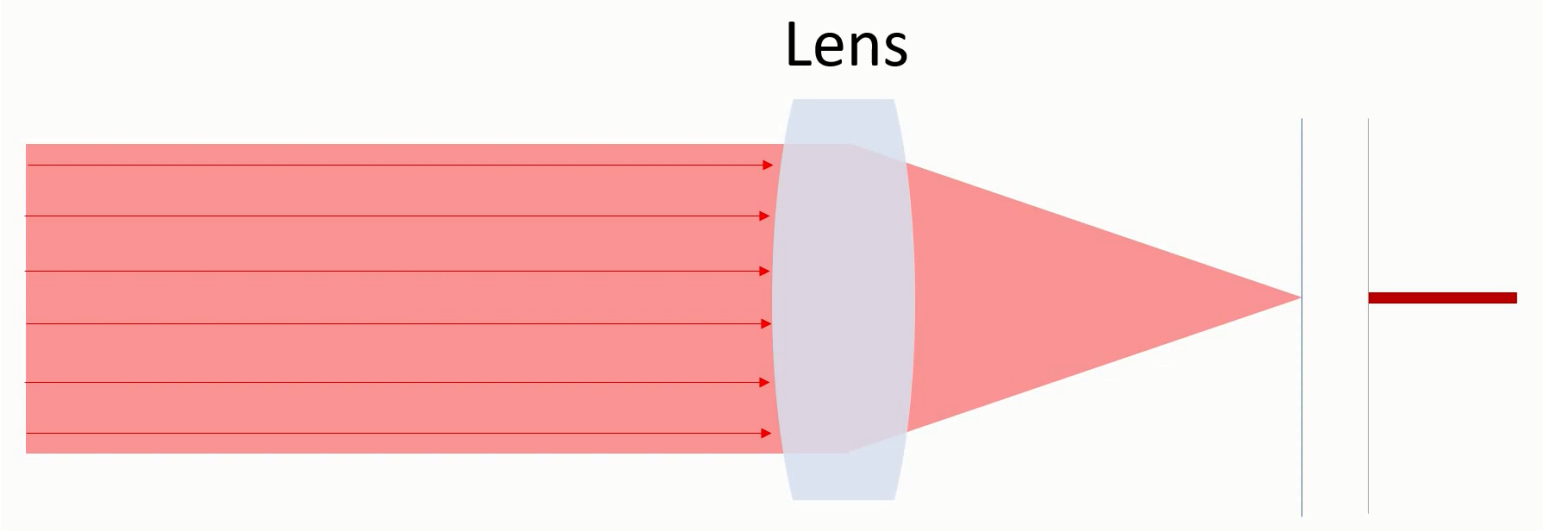
Picture Source: https://slideplayer.com/slide/13964739/

Optical Diffraction Grating (cont.)



Picture Source: “Diffraction Gratings | A-level Physics | OCR, AQA, Edexcel”, “SnapRevise” channel on YouTube.

Uniform light beam



Picture Source: “Fourier Optics used for Optical Pattern Recognition”, “Huygens Optics” channel on YouTube.

A mask with pattern in the way of light beam

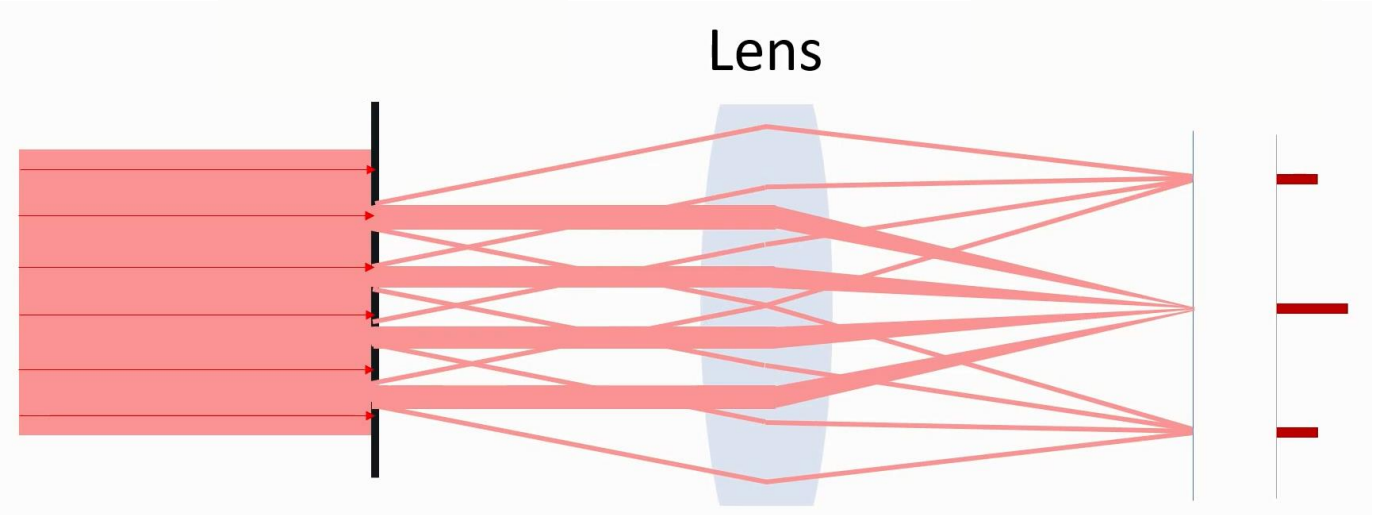


Figure 1.

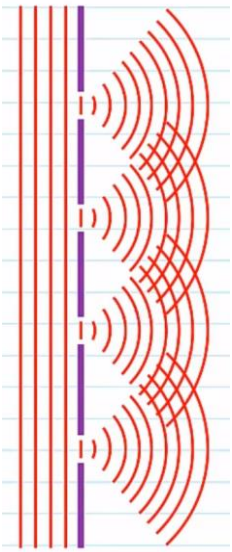
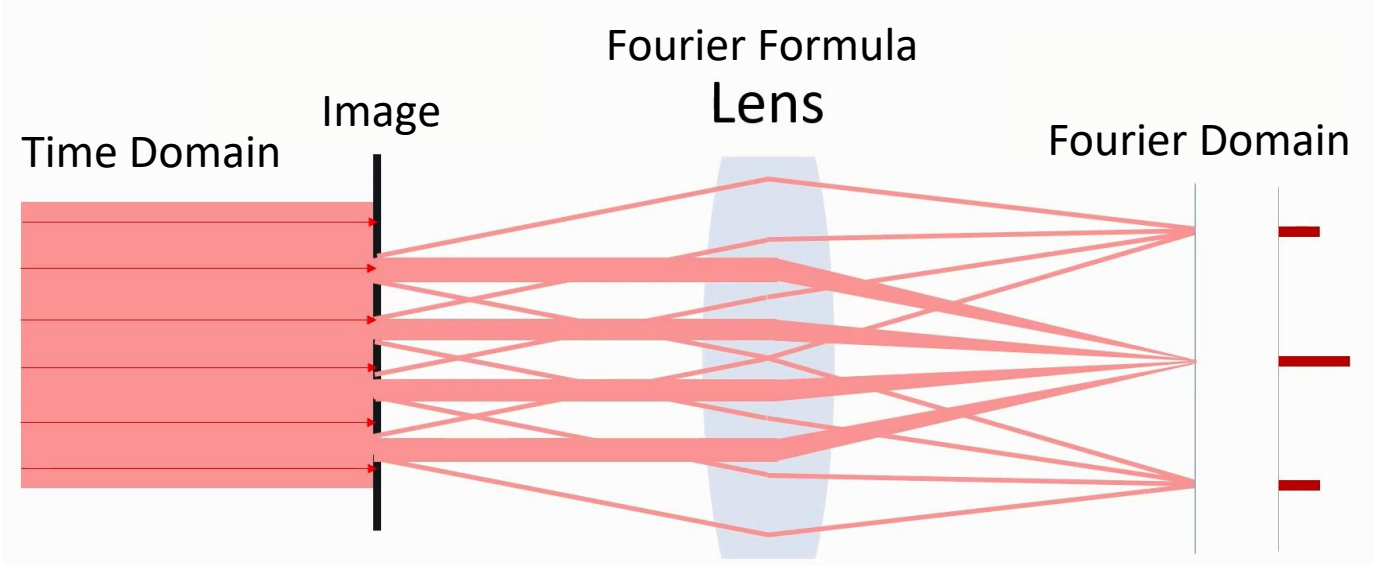


Figure 2.

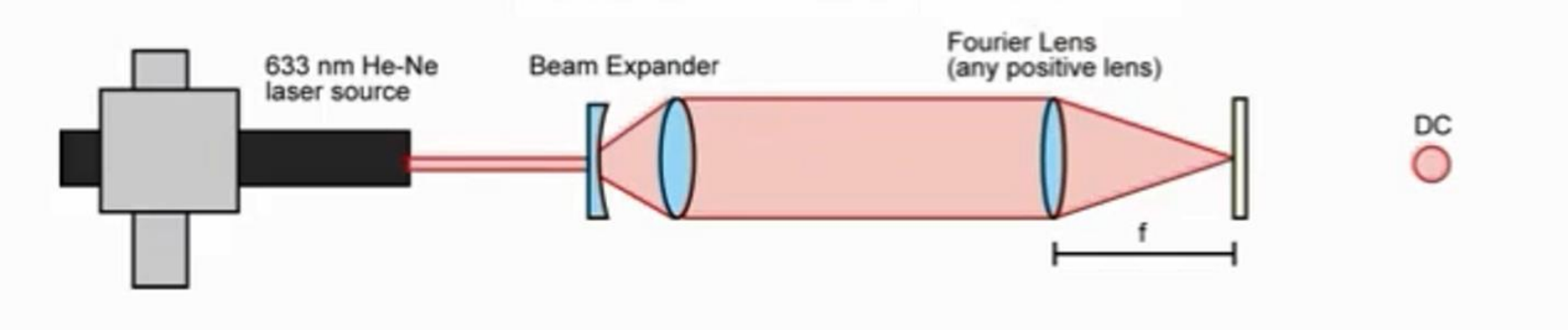
Picture Source: (1) “Fourier Optics used for Optical Pattern Recognition”, “Huygens Optics” channel on YouTube. (2) “Diffraction Gratings | A-level Physics | OCR, AQA, Edexcel”, “SnapRevise” channel on YouTube.

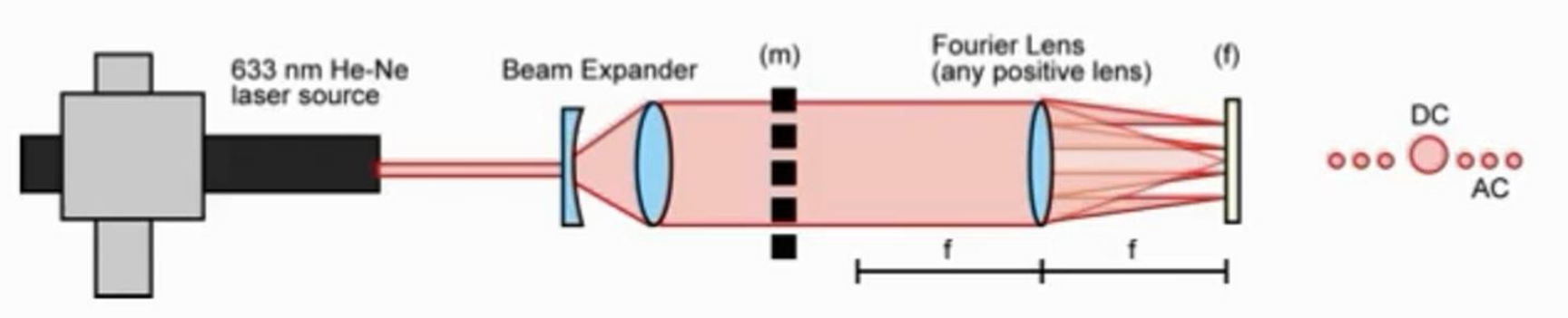
Fresnel and Fourier



Picture Source: “Fourier Optics used for Optical Pattern Recognition”, “Huygens Optics” channel on YouTube (with modifications).

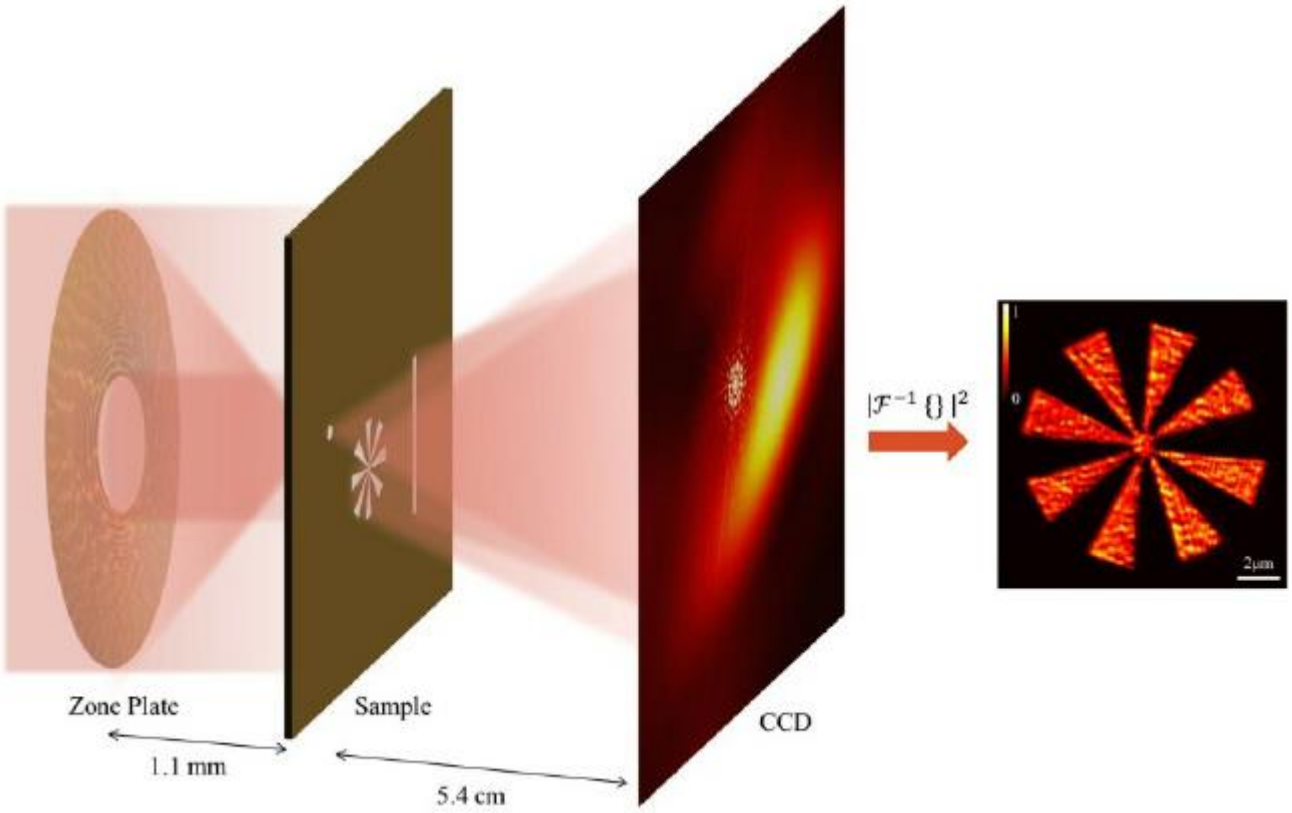
Fourier Optics Setup





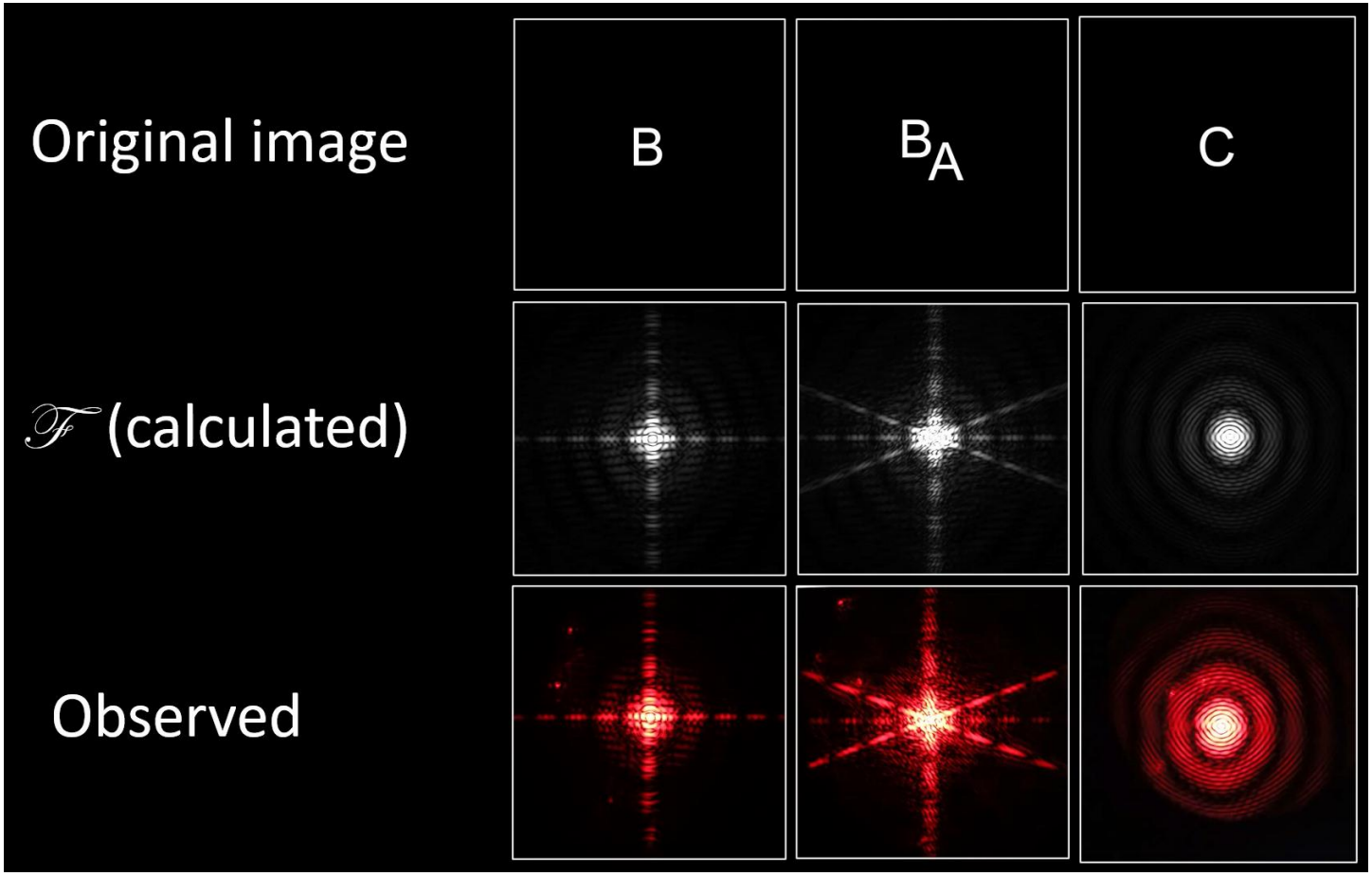
Picture Source: Optics for Engineers, at University of Cincinnati, Lecture 6A, by Dr. Jason Heikenfeld.

Fourier Optics Setup (cont.)



Picture Source: Malm, Erik & Monserud, Nils & Brown, Christopher & Wachulak, Przemyslaw & Xu, Huiwen & Balakrishnan, Ganesh & Chao, Weilun & Anderson, Erik & Marconi, Mario. (2013). Tabletop single-shot extreme ultraviolet Fourier transform holography of an extended object. Optics express. 21. 9959-66. 10.1364/OE.21.009959.

Calculated vs observed frequency domain



Picture Source: “Fourier Optics used for Optical Pattern Recognition”, “Huygens Optics” channel on YouTube.

Calculated vs observed frequency domain (cont.)

- It takes about 2 seconds for a Intel Core i5 computer to calculate the Fourier transform of each image presented in the previous slide.

- In a Fourier optic setup, the only limitation is the speed of light. So it takes only 0.3 ns to perform each transform for the setup proposed in the reference.

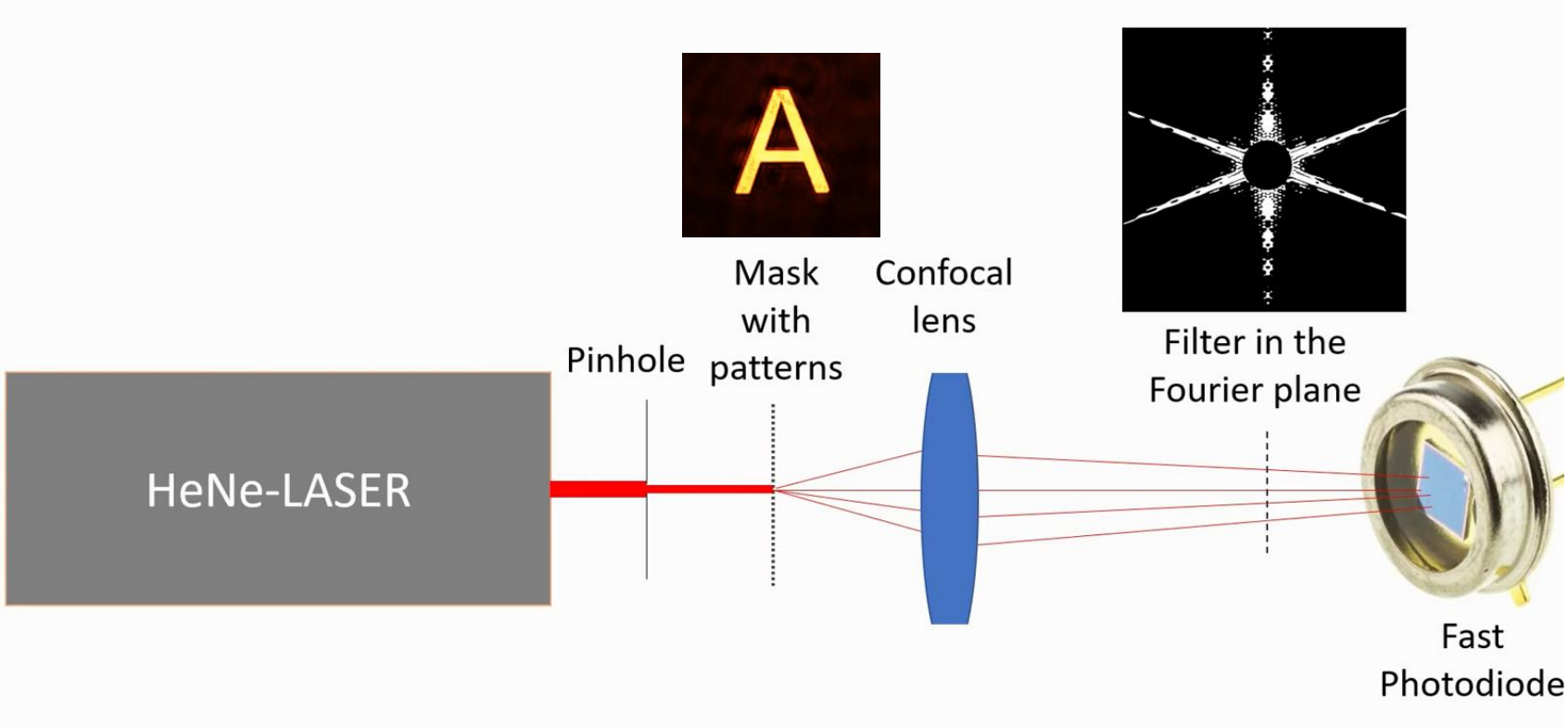
6 billion times faster!

Electron vs Photon

Electron	Photon
It is matter.	It is energy.
It has mass.	It has no mass.
It carries a negative charge.	It doesn't carry any charge.
The speed of an electron can be zero or anything under the speed of light. It is impossible for an electron to achieve the speed of light.	Photon travels at the speed of light.

Picture Source: https://byjus.com/physics/electrons-and-photons

Example: Pattern Recognition

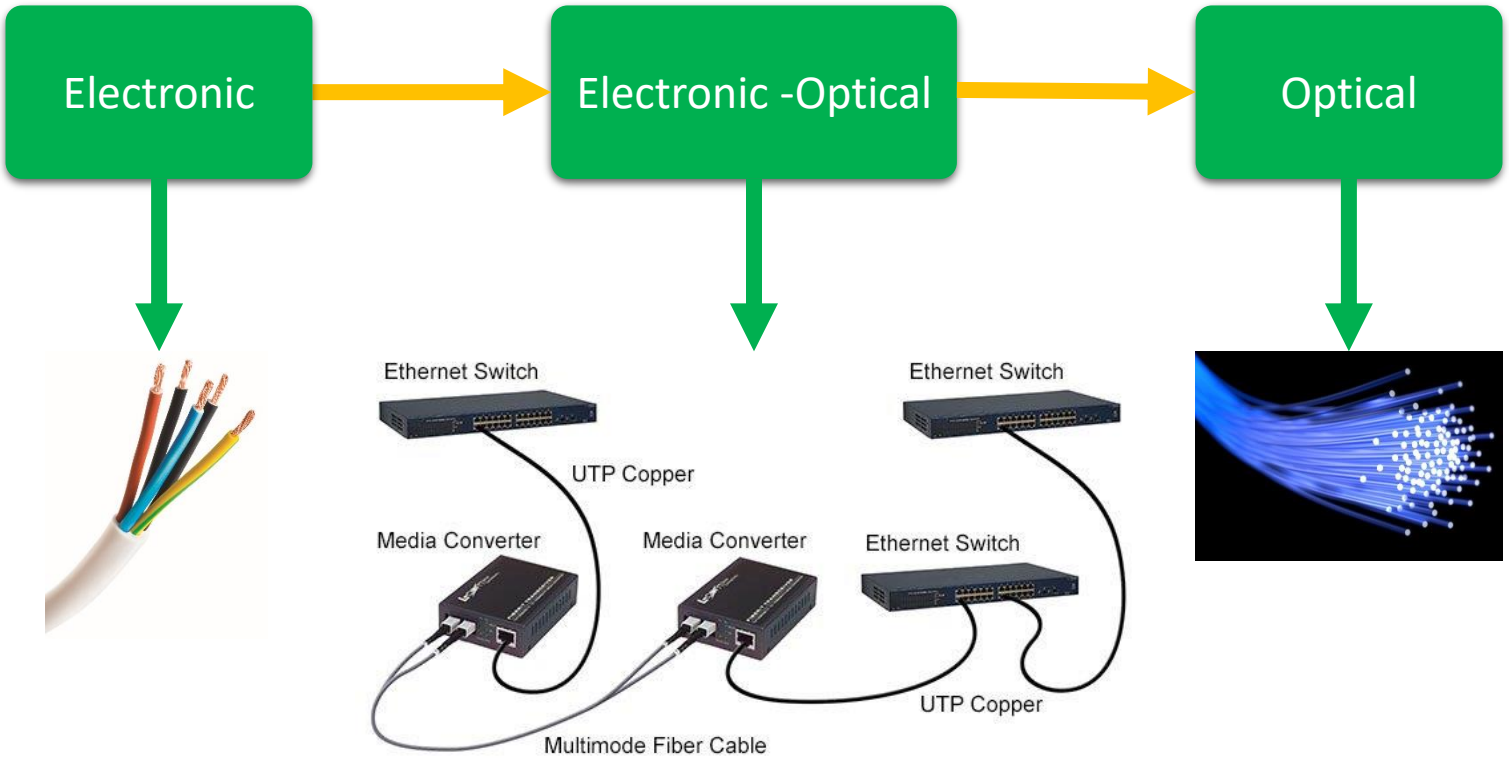


Picture Source: “Fourier Optics used for Optical Pattern Recognition”, “Huygens Optics” channel on YouTube.

Fourier optics implementations

- Optical signal processing
- Optical computing
- Quantum computing
- Crystallography (covered in assignment 10)

Optical computing




The END!