Optics

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Journal Club

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Geometrical optics

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Exceptions

- Focus
- Long propagation
- Diffraction optical elements
  e.g. gratings.

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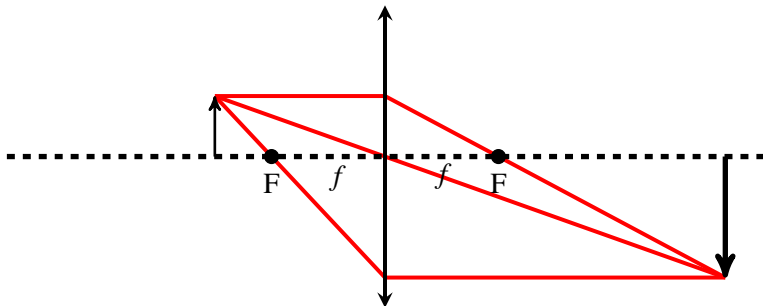
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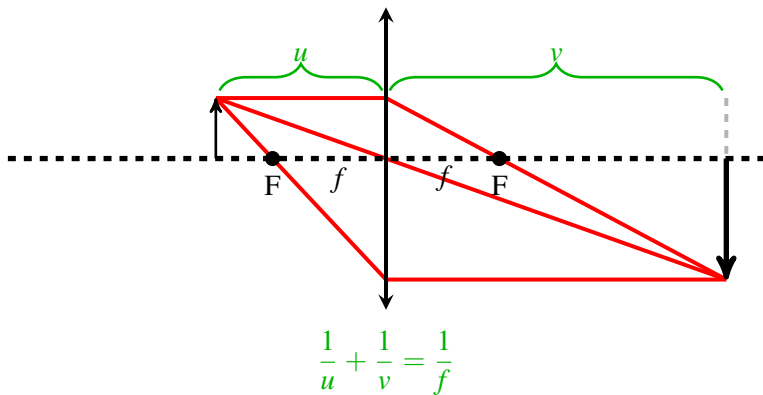- Diffraction optical elements
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Ideal Lens
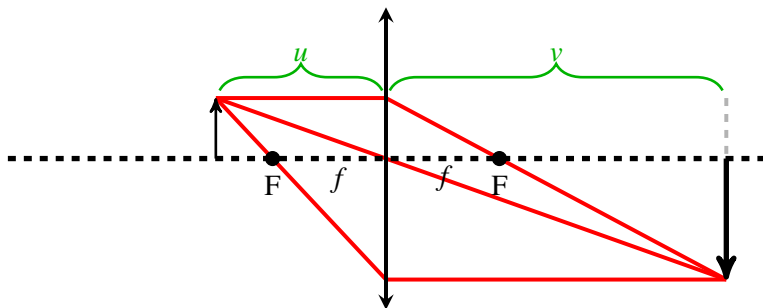

F $\quad f \quad\quad f \quad$ F

Ideal Lens
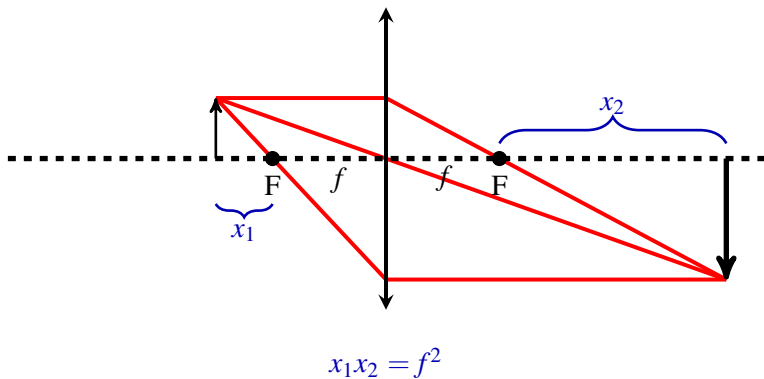

$$\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$$

Ideal Lens

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$$M = \frac{v}{u}$$

Ideal Lens

$$x_1 x_2 = f^2$$
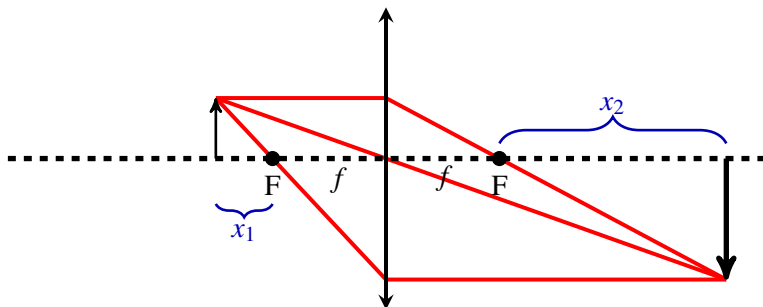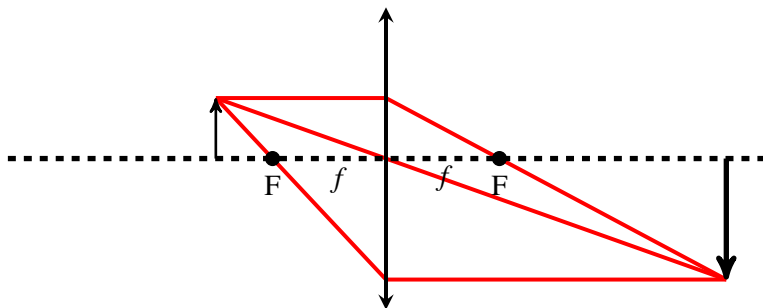
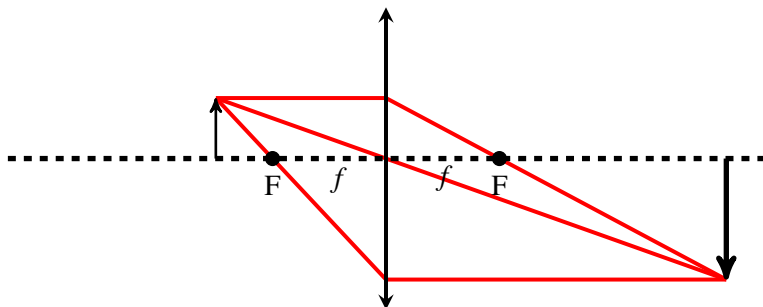# Ideal Lens

$$x_1 x_2 = f^2$$

$$M = \frac{f}{x_1} = \frac{x_2}{f} = \sqrt{\frac{x_2}{x_1}}$$
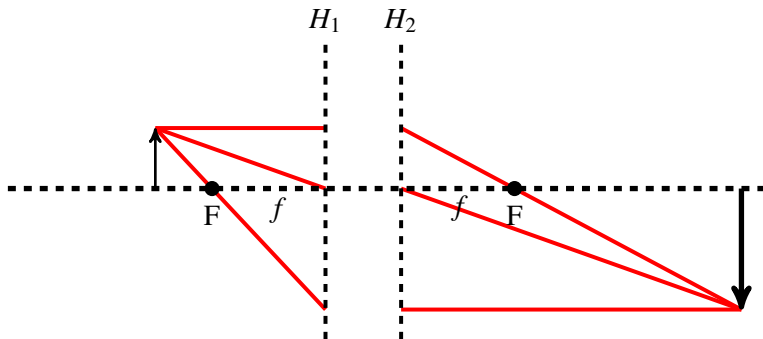
Ideal Lens

Conjugate plane: Perfect image under ray optics
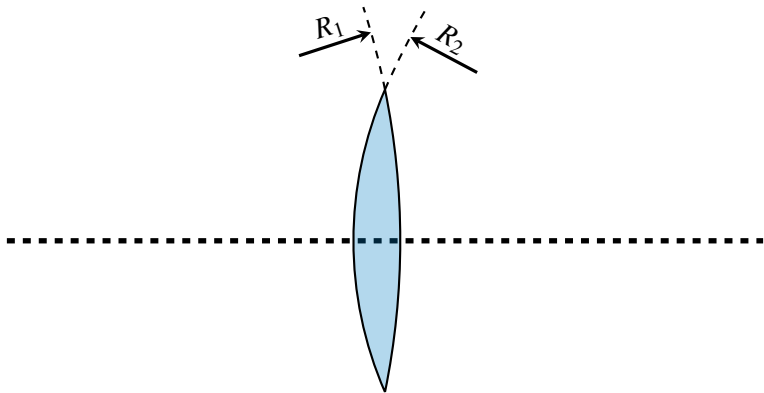
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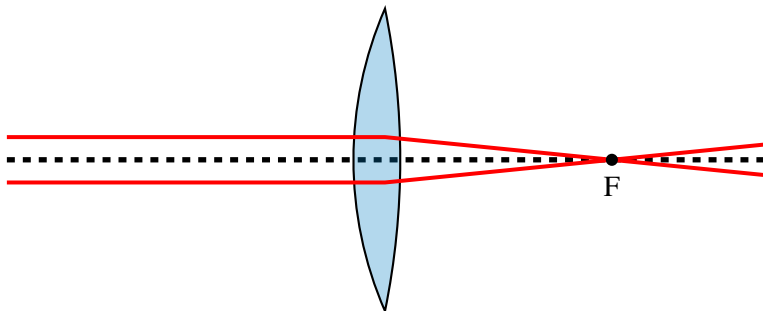Principal planes: Conjugate plane where $M = 1$
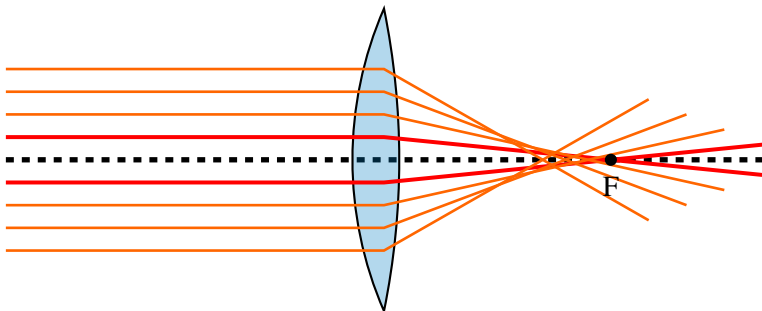
Ideal Lens

Spherical lens

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F

Spherical lens

F
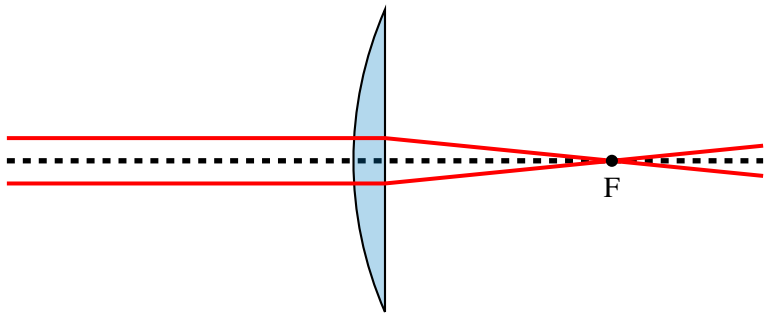
Aspherical lens
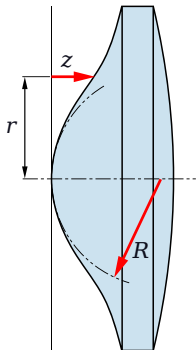
Aspherical lens
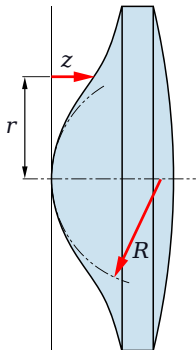
Use cases

- Collimation
- Fiber coupling

Other lens types

Reflective

- No chromatic shift
- Can be aspherical
- More difficult beam path layout

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Lens set

- Could fix chromatic shift
- Could fix monochromatic aberration
- Better surface quality
- May not be UV compatible

Fiber coupling

Collimation
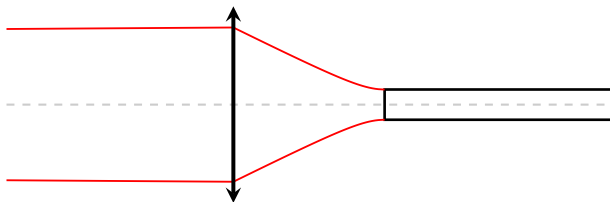
Fiber coupling
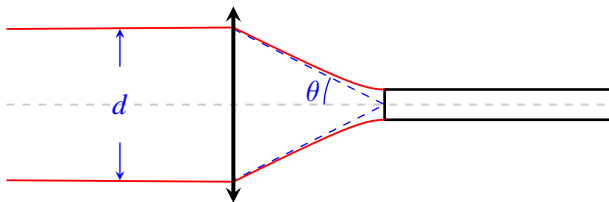
Collimation

Fiber coupling

Collimation

$$d \approx 2f \tan \theta$$

Fiber coupling

Alignment

Fiber coupling

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Fiber coupling
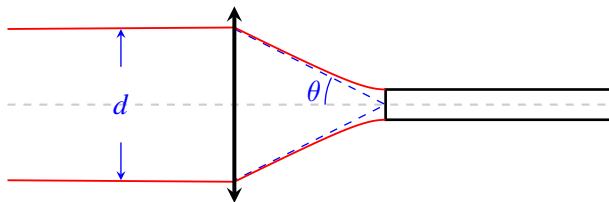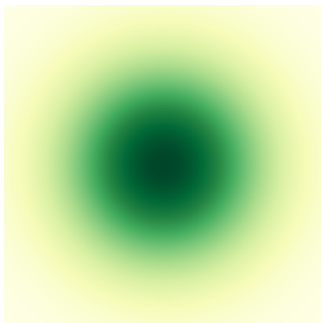
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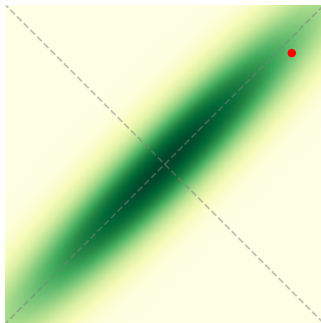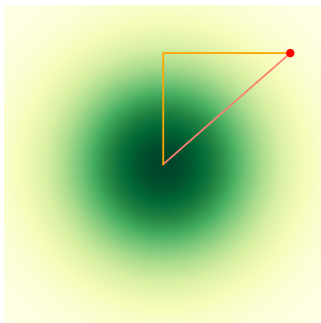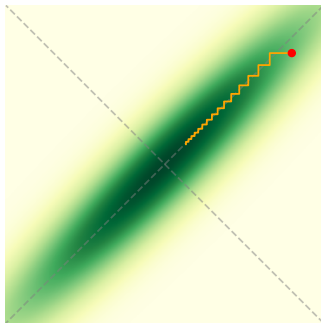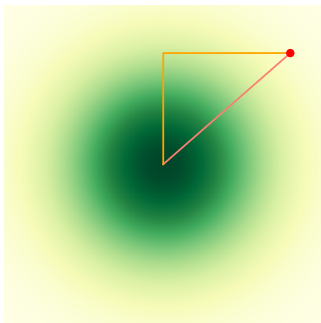
Alignment

Polarization

Polarization: Polarizers
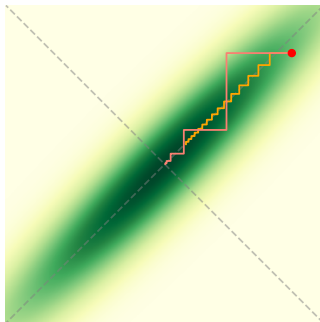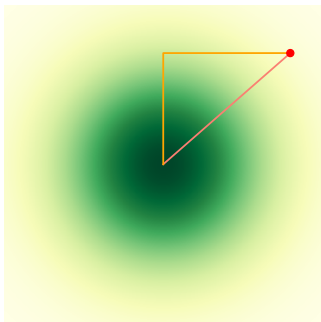
Polarization: Polarizers

PBS Cubes

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- Based on coating
- Easy to use for both polarizations
- OK loss (few %)
- low-mid extinction
- Wavelength dependent

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- Non 90 reflection angle
- Low loss
- High extinction
- Etaloning
- Broadband

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Polarization: Waveplates

$$\Delta\phi = \frac{2\pi nl}{\lambda}$$

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Other WP type: Achromatic, "Magic"

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Normal incident

- π phase shift
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Simple surface

- (metal or dielectric)
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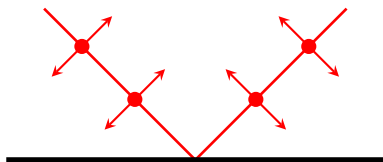
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Polarization: Effect of reflection

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Coating

- "Arbitrary" phase shift
- Change relative amplitude
- (dielectric mirror, dichroics)
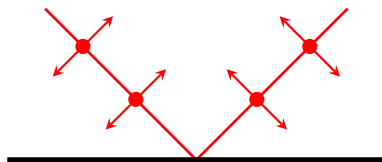
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Electro-optic modulator (EOM)

Electro-optic modulator (EOM) i.e. electrically variable waveplate

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DC EOM: adjustable waveplate

- Rotate polarization
- (with polarizer) Turn beam on/off
- Temperature drift compensation

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Electro-optic modulator (EOM) i.e. electrically variable waveplate

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AC EOM: phase/polarization modulation

- Polarization modulation
- Power modulation
- Phase modulation/sideband
- Asymmetric sideband

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$$\phi = \phi_0 + \beta \sin(\omega t)$$
$$\tilde{A} = A_0 \exp(i\phi)$$
$$\quad = \tilde{A}_0 \exp(i\beta \sin(\omega t))$$
$$\quad = \tilde{A}_0 \sum_{n=-\infty}^{\infty} J_n(\beta) \exp(in\omega t)$$

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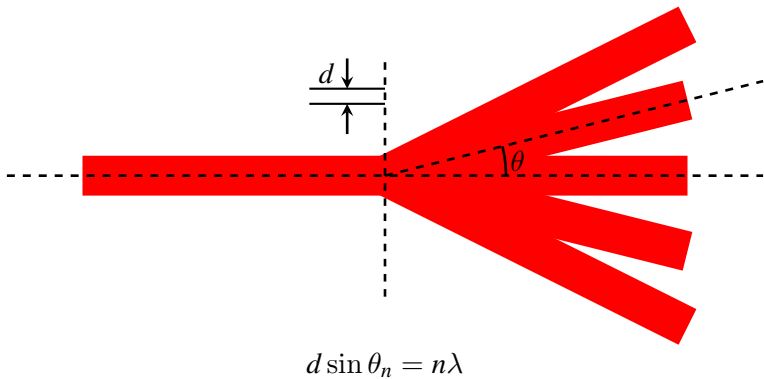- Asymmetric sideband: sawtooth drive

$$\phi = mod(\phi_0 + \omega t, 2\pi)$$
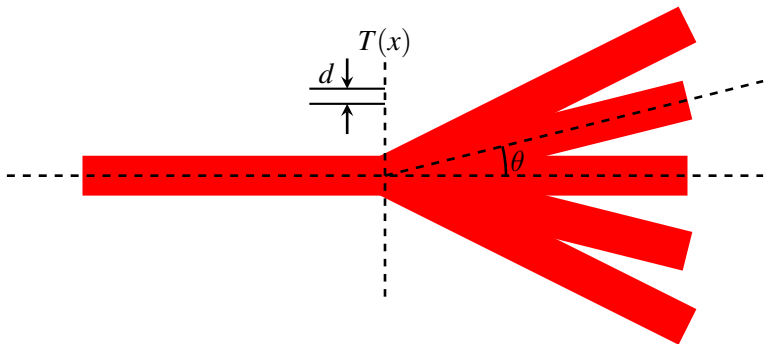
Acousto-optic modulator (AOM)

Acousto-optic modulator (AOM) i.e. dynamic/moving grating

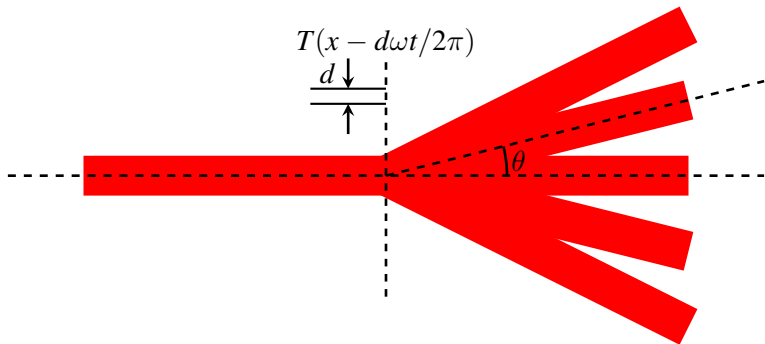# Acousto-optic modulator (AOM) i.e. dynamic/moving grating

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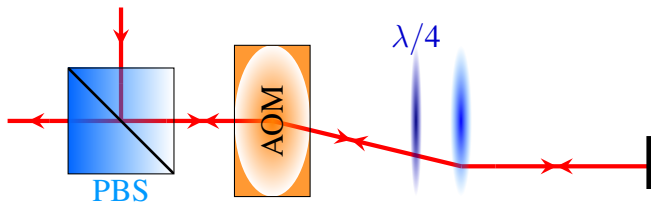

$$d \sin \theta_n = n\lambda$$

$$T(x) = \sum_n a_n \exp\left(\mathrm{i}\frac{2n\pi(x - d\omega t/2\pi)}{d}\right)$$

$$= \sum_n a_n \exp\left(\mathrm{i}\frac{2n\pi x}{d} - \mathrm{i}n\omega t\right)$$

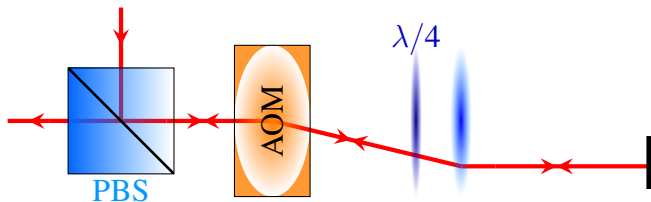# Acousto-optic modulator (AOM) i.e. dynamic/moving grating

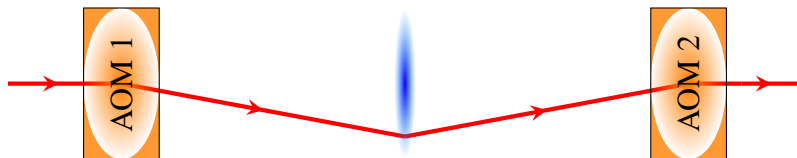# Acousto-optic modulator (AOM) i.e. dynamic/moving grating

Double Pass

Acousto-optic modulator (AOM) i.e. dynamic/moving grating

Double Pass

Tandem

AOM vs EOM