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Practical geometric optics

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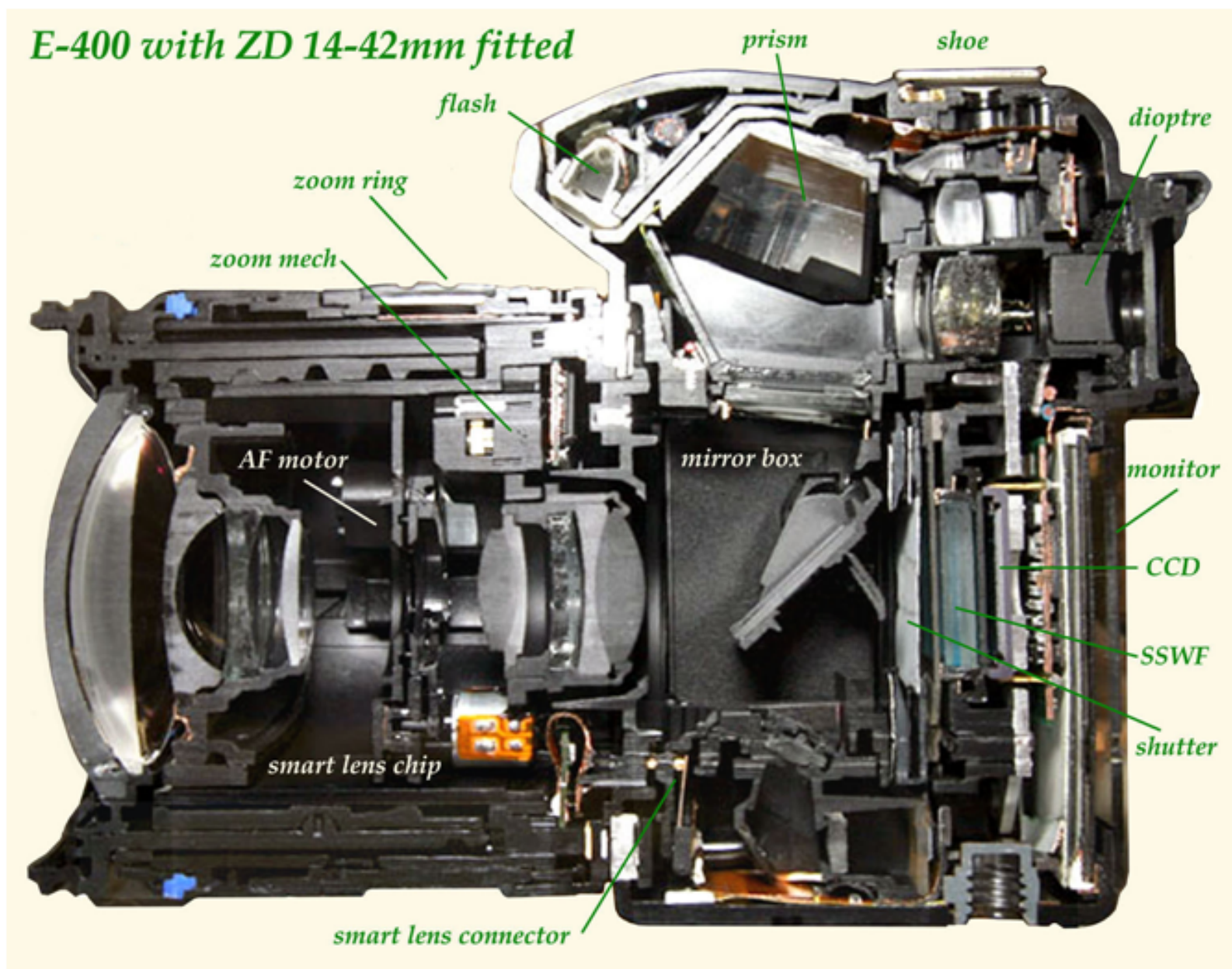
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Outline of the talk:

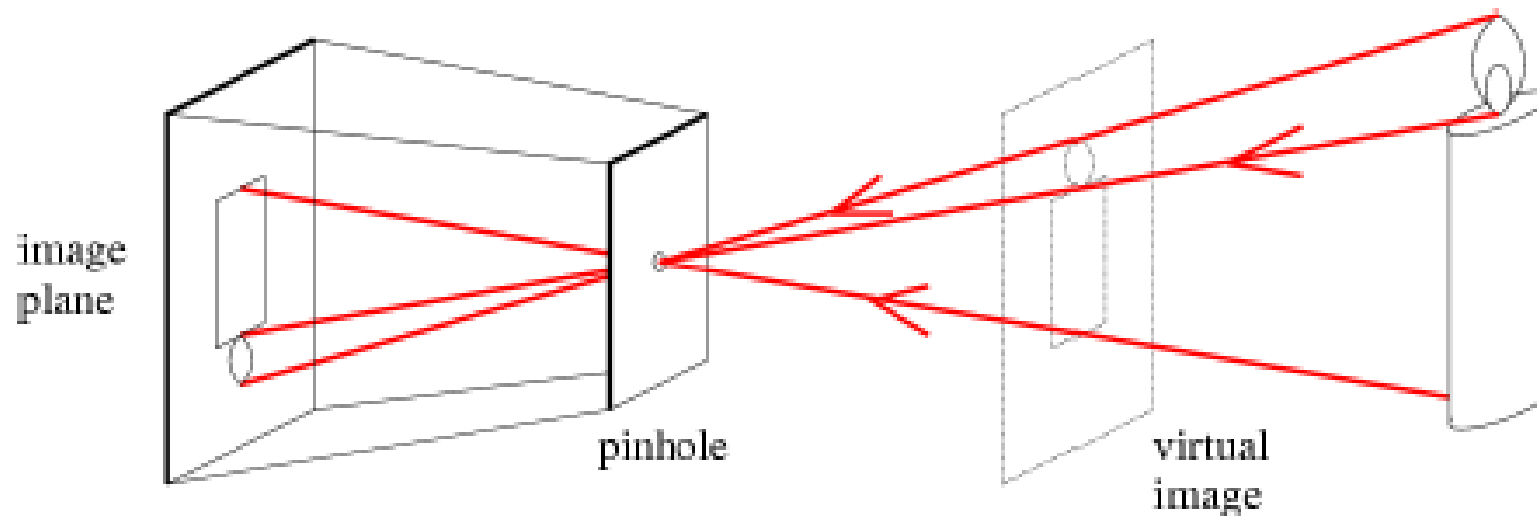
- ◆ Motivation, camera lens.
- ◆ Geometrical optics.
- ◆ Why lenses?
- ◆ Depth of field.

An SLR



A pinhole

- ◆ 15th century, Florence architect Filippo Brunelleschi (1377-1446) uses pinhole as a tool for perspective drawing
- ◆ 16th century, spreads in use, camera obscura (lat.)
- ◆ 1822 Frenchman J.-N. Niepce adds a photographic plate \Rightarrow first photograph.



Size of hole in the pinhole

A trade-off:

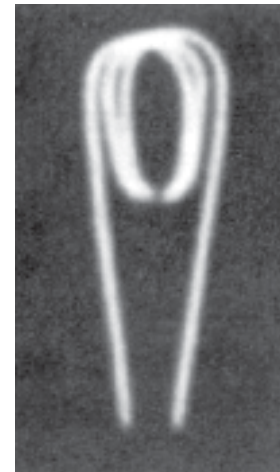
- a. A bigger hole takes in a bigger amount of light, but leads to more blur.
- b. When the hole approaches the wavelength of light, diffraction becomes an issue. This also leads to blurring.
- c. It is possible to derive an optimum for the image resolution. E.g. for $f=100$ [mm] and $\lambda=500$ [nm], the optimal hole size is dirky 0,32 [mm].



a



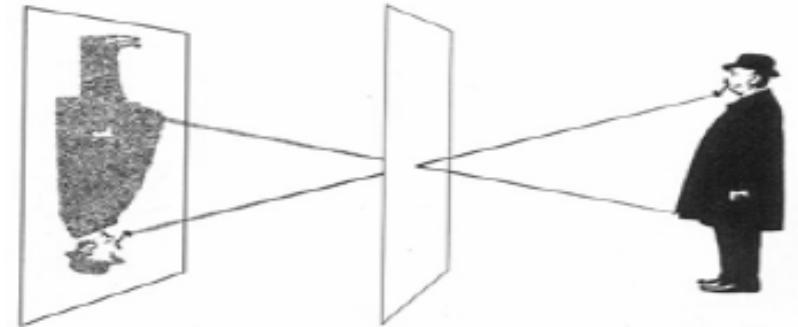
b



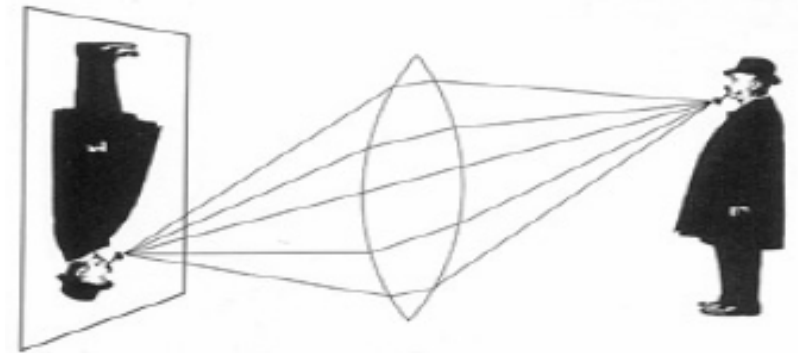
c

Why lenses?

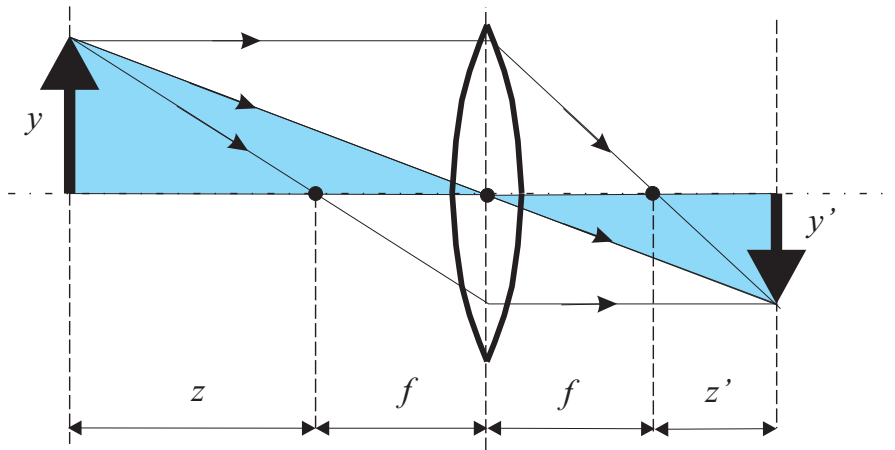
- ◆ Collects low number of photons
- ◆ Bumps into the diffraction limit



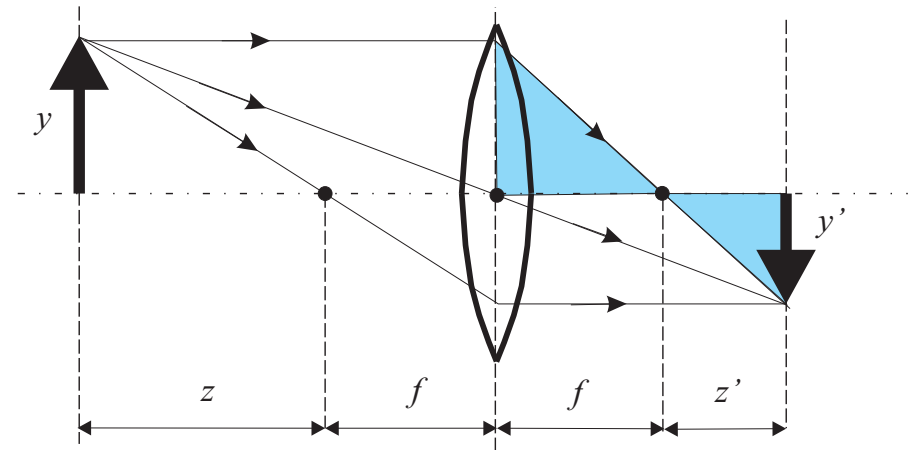
-
- ◆ Collects more photons
 - ◆ Can be focused



Thin lens equation, similar \triangle



$$\frac{y'}{y} = \frac{z' + f}{z + f}$$



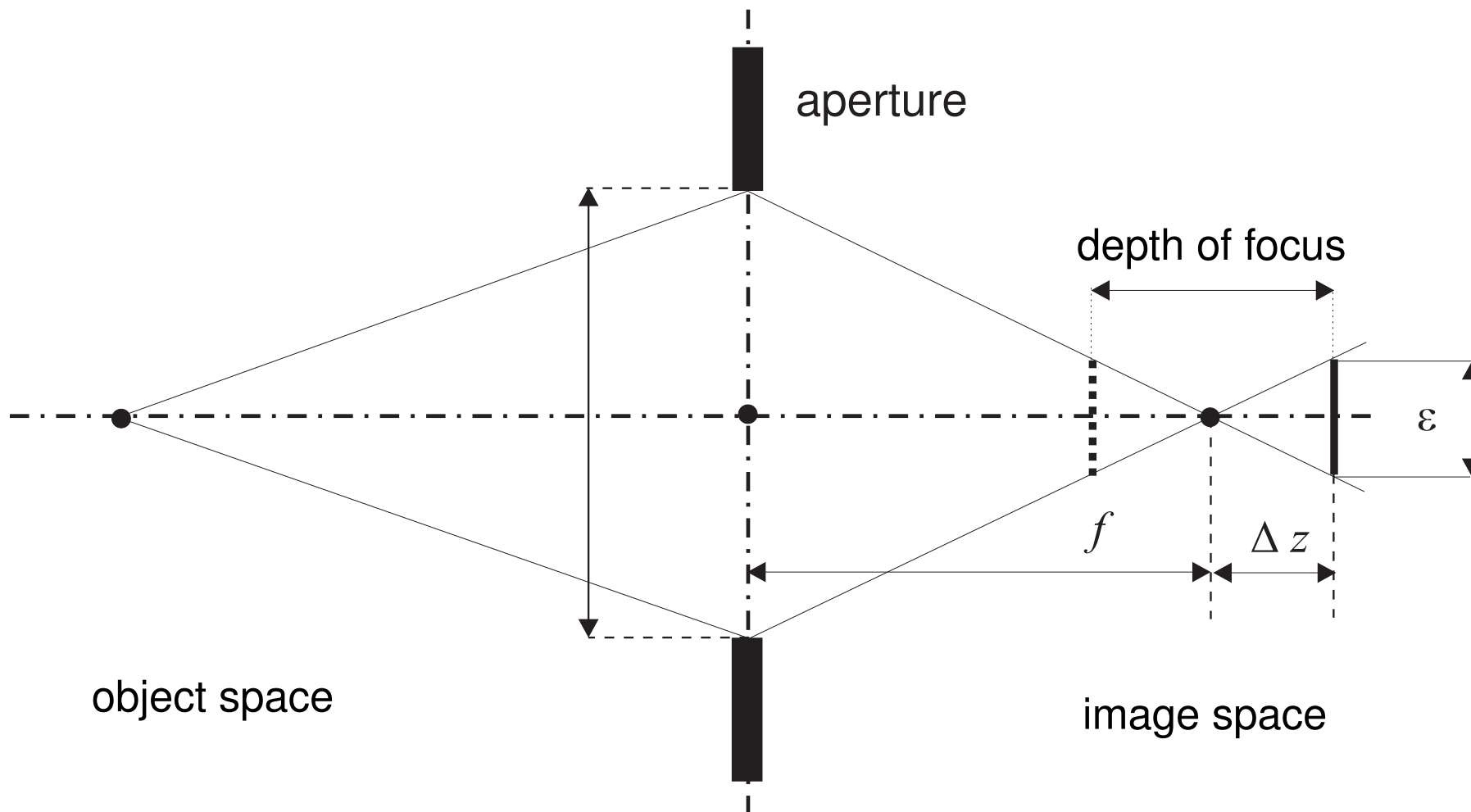
$$\frac{y'}{y} = \frac{z'}{f}$$

This gives:

$$\begin{aligned} \frac{z' + f}{z + f} &= \frac{z'}{f} \\ f(z' + f) &= z'(z + f) \\ fz' + f^2 &= zz' + fz' \\ f^2 &= zz' \end{aligned}$$

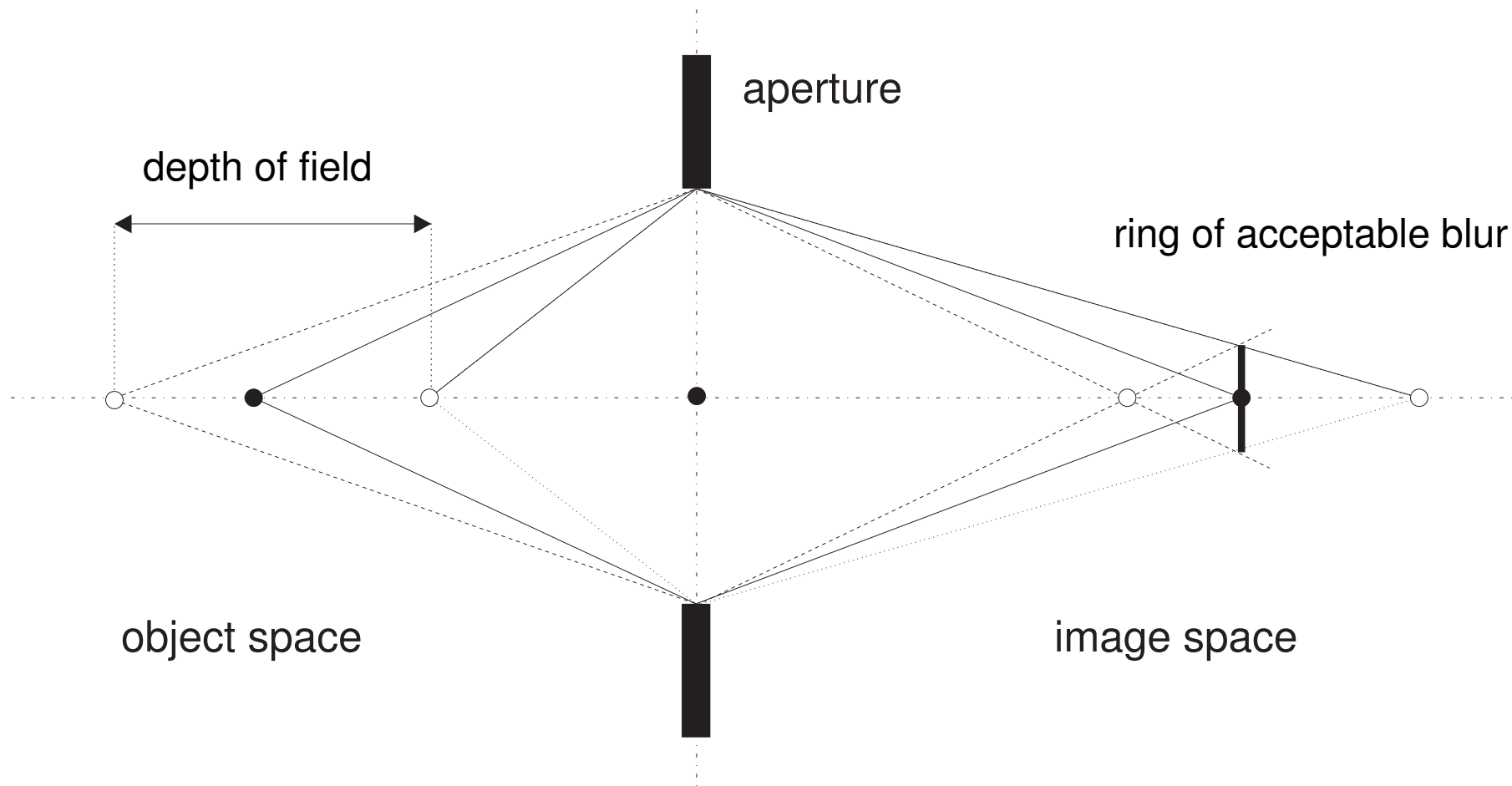
Depth of focus

It is possible to shift an image plane a little bit and still have a good sharpness. This is because pixel size is finite, size is ϵ .



Depth of field

Depth of field (DOF) specifies the range of distances in the object space for which the points are images sharply on the image plane. This is of practical interest in photography and industrial imaging.



DOF, example



Dependence of DOF on aperture size



big aperture, low DOF



small aperture, big DOF

Dependence of DOF on focal length





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