Exercises on properties of projection instruments

Microscope objective

The following characteristics are written on a microscope objective: 2.5, 160/0.07. The first one is the magnification, the second one is a mechanical distance characterizing the position of the image, and the third is the numerical aperture. To the mechanical distance of 160mm corresponds an optical distance of 180mm between the second focal point of the objective and the image (F'A').

Calculate the following quantities:

- focal length of the objective
- distance FA between the first focal point and the object
- angle of aperture α in the object space (in degrees)
- angle of aperture α' in the image space (in degrees)
- front focal length (distance of the object to the lens, assuming a thin lens)
- back focal length (same in the image space)
- diameter of the aperture stop, assuming it is located in the second focal plane of the objective
- diameter of the field of view in the object space, assuming a 10mm reticule limits the size of the image
- resolution in the object space, as limited by diffraction
- resolution in the image space, to be compared to one tick on the reticule (100 ticks over the whole reticule) or to the typical size of a pixel of a CCD detector
- depth of field in the object space, as limited by diffraction

The same quantities can be calculated and compared for a microscope objective: 10, 160/0.25.

Digital camera

A digital camera is equipped with a 35mm focal length objective and a 10 megapixel detector. We will assume that the pixel size p is 6 µm and the aspect ratio of the detector is 10x15.

Calculate the total size of the detector in number of pixels and in mm.

Calculate the field of view in the object space for an object at infinity and for an object at D=5 meters.

What must be the f-number N of the objective if we want the resolution to be limited by diffraction?

In practice we use a smaller value of N, say N=3.Why?

What is the resolution limit in the object space in the case of an object at infinity or at D=5m?

Calculate the depth of field around an object at 5m for N=3.

Calculate the hyperfocal distance for N=3.