OPTICAL DESIGN – WHAT IS INSIDE THE BOX AND WHY?

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Abstract: In this tutorial we shall discuss, from a practical point of view, basic principles of optical design applied to optical microscopy.

Starting from basic definitions we overview aberrations present in optical systems and discuss ways to evaluate the performance of the optical system, e.g. using Strehl ratio, modulation transfer function, transverse ray aberrations, etc. We shall then discuss simple optical systems, starting from singlets, doublets and combination of lenses used most frequently in optical microscopy, with especial emphasis on 4-f systems, scan lenses and microscope objective lenses. In context of the latter, we review different types of objective lenses (Lister, Amici, etc) and look at how these are designed which in turn will debunk some of the mysteries many associate with these mysterious objects.

We shall discuss issues relating to changing the tubelens - objective lens distance, the thickness and quality of the beam splitter and its ideal position, and other factors all researchers designing optical microscopes should be aware of. We analyse the best configurations for optical scanners and their use in conjunction with microscope objective lenses and discuss how important descanning really is. In terms of the detector lens and the pinhole used in confocal microscopes, we look at alternative designs, such as application of zoom lenses to replace mechanically adjustable pinholes.

We shall review basic techniques that permit compensation of aberrations arising from the sample or erroneously set up optical systems. Design strategies will be discussed to avoid or work around these aberrations. Finally, we look, via practical examples, at various applications and imaging modes of optical microscopy to identify how much effort should be put into designing and building different imaging modalities.

The tutorial assumes very little optics knowledge and contains *little mathematics*. It is especially designed to engage engineers, physicists, biologists and medical researchers. There will be time to ask questions and discuss individual design problems.