



# Optical design and unification of optical systems of objectives for microscopes

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**SPIE. OPTICAL SYSTEMS DESIGN** Frankfurt Fairgrounds, Germany, 15 May 2018

**ABSTRACT.** The optical design as a result of the synthesis of optical elements with known base aberrations properties is the basis for the unification of optical systems of objectives for microscopes. Technical parameters, optical circuits, optical and mechanical structures are subject to unification.

**1. INTRODUCTION.** The idea to consider the unification parameters in the optical calculations stage can be implemented by using some basic optical components with a priori known dimensional and aberrational properties in the objectives optical systems. Some paper - Rusinov M.M., "Technical optics", Leningrad Mechanical Engineering, (1979) offers the theoretical basis for application of basic optical components with known dimensional and aberrational properties and proposes options for their arrangement within original optical schemes.

**2. BASIC COMPONENTS, UNIFICATION OF OBJECTIVE OPTICAL STRUCTURES.** The existing dependence of "N" quantity of single lens elements on the entrance numerical aperture  $N=2.5A_{ob}$  rounded to a whole number allows calculating achromatic microobjectives with different numerical apertures:



Figure 1. Optical schemes of objectives with achromatic aberration correction. Basic components use unification

Description of unified optical designs for objectives with plan achromatic type of aberration correction can be another example. Here the dependence of selection of single base components quantity N is a little more complicated, since another base component of meniscus shape with the concave side facing the image space is added in the optical construction. There is also a dependence in the ratio of radii values of this component. Figure 2 shows the optical schemes of objectives with plan achromatic correction of aberrations. The unified optical design of plan achromats is presented as the synthesis of three types of basic components:

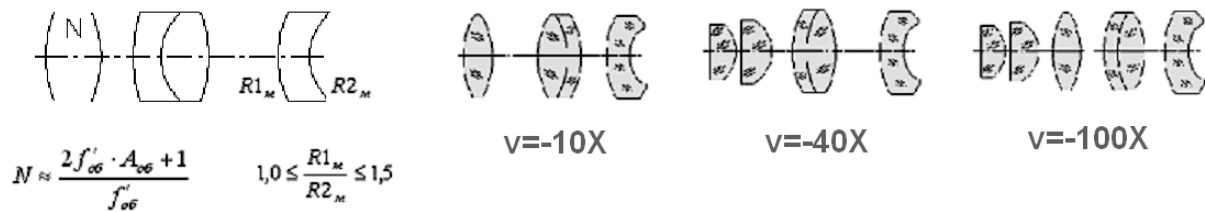
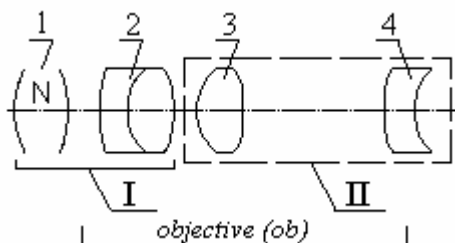


Figure 2. Optical schemes of objectives with plan achromatic aberration correction.

Not only the individual base components can be standardized, but also their combination. In this case, the dependence of the choice of the number of certain unified components can change. As an example, we can cite the designs of standardized objectives for a microscope, which contains two components, the first (I) of which includes "N" frontal positive lenses "1" and a double glued lens "2", and the second (II) consists of a single positive lens "3" and a meniscus "4". By using this design, to obtain variants of a plan achromatic microscope objectives with different linear magnification and input numerical aperture. The number of front positive components "N" in the optical scheme of a particular lens is chosen from the relation:



$$N = \frac{f'_{II}}{f'_{ob}} - 1$$

where  $f'_{II}, f'_{ob}$  – the reduced focal lengths of the second component and the objective as a whole, respectively.

Figure 3. The optical circuit of objectives having a plan achromatic correction of aberrations.

It should be noted that optical designs of objectives with plan fluor aberration correction are also unified. However, this is a more complex unification:

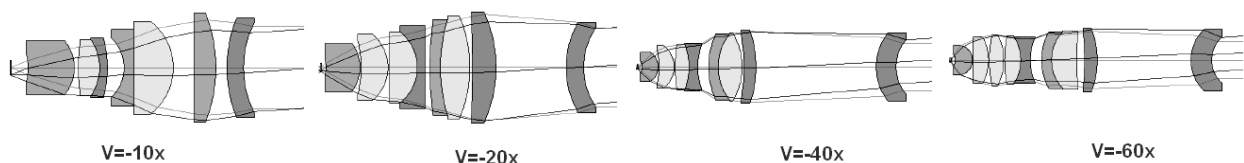


Figure 4. Unified designs of objectives plan fluors.

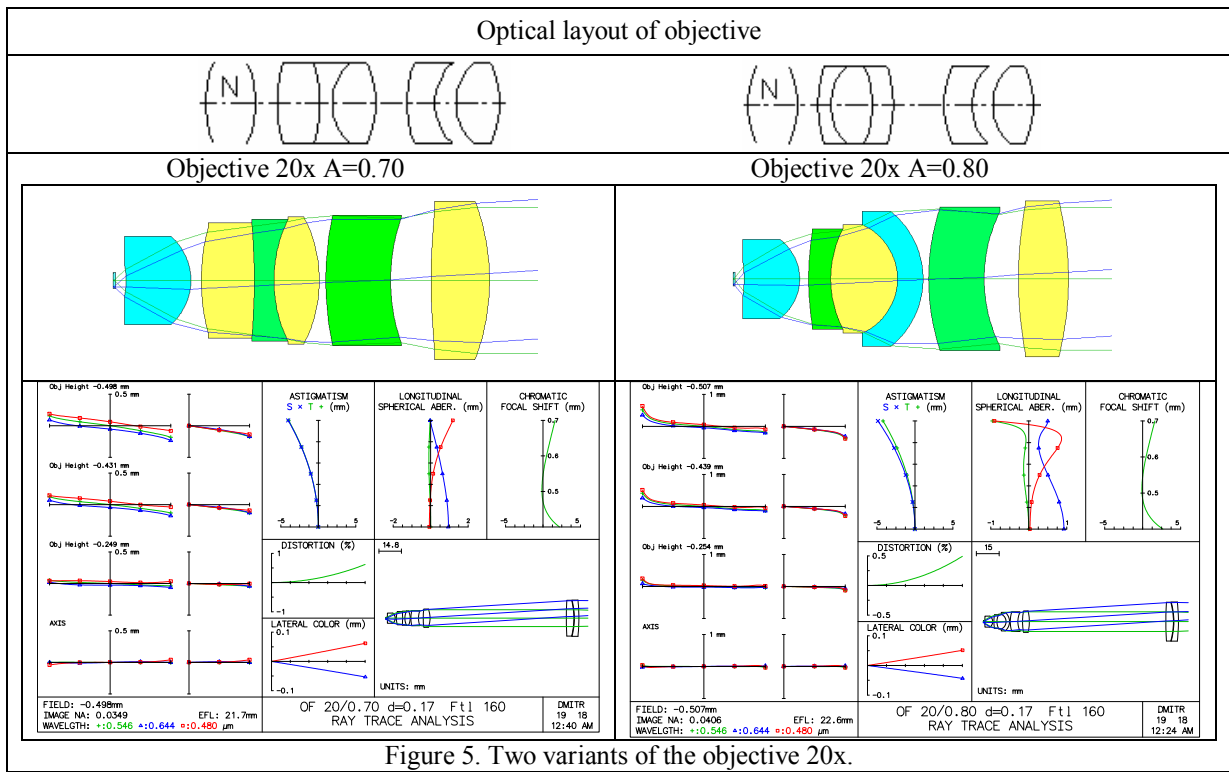


Figure 5. Two variants of the objective 20x.

**3. CONCLUSION.** In modern microscopy, there have been steady trends towards a broad unification of objectives for microscopes. In the development of objectives with unified parameters, it became necessary to change the methods and approaches to optical design, design and technology of manufacturing parts, assembly of objectives for microscopes. To achieve the goal, the search for the most rational designs is under way, new optical materials are being developed and introduced into production, the methods of construction are being improved, and the qualifications of specialists are being improved. It is shown that the basis of unification of optical systems of objectives for microscopes is the use of optical design as a tool for creating a composition of elements with known dimensional, aberration properties. It is shown that it is possible to provide interchangeability of objectives for the assembly of microscopes of various manufacturers.