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Comparison of the geometrical parameters of one-lens and two-lens systems for rainbow holography*

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1. Introduction

In the recent years a one-step rainbow holography [1, 2] has been suggested and developed. Unlike the conventional two-step Benton method [3] in which the real image from a primary hologram was used, the one-step technique employs a lens projected real image in the recording process. For the fabrication of the one-step rainbow holograms we need a narrow horizontal slit in imaging system. When the slit is placed just behind the lens (or in the distance of a) we have the pseudoscopic geometry (Fig. 1). The alternative arrangement to produce an orthoscopic holographic image is shown in Fig. 2.

In orthoscopic case the slit is placed between the object and the first focal plane of the imaging lens (Fig. 2).

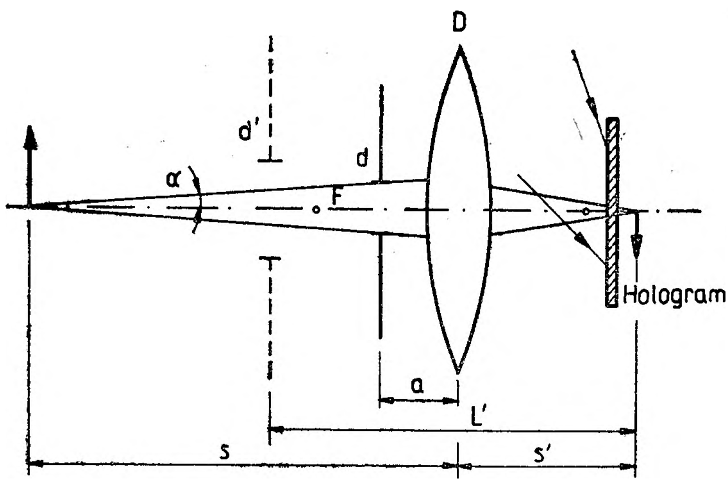

Fig. 1. Optical system for pseudoscopic one-lens rainbow hologram

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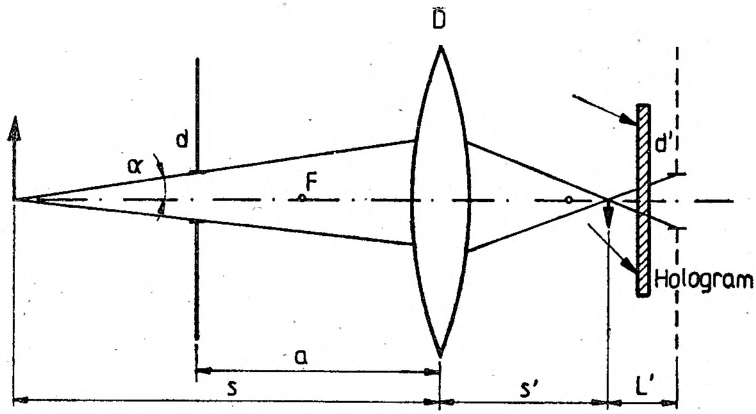

Fig. 2. Orthoscopic one-lens rainbow holography

2. Aperture angle in one-lens and two-lens optical systems

Although one-step imaging by one-lens rainbow holography is a simple and promising technique, the resolution in the pseudoscopic technique is more limited than in the orthoscopic one, due to the slit place. Similarly, we can find this in vertical field of view in orthoscopic geometry. Recently, we have proposed a two-lens system in which these restrictions may be alleviated, [4], it is, an afocal system with magnification 1 : 1. The slit is placed between the lenses (Figs. 3, 4).

It can be shown that the aperture angle in the one-lens systems is given by

$$\alpha = \frac{d'}{2}\frac{f}{L'(s-f)}. \tag{1}$$

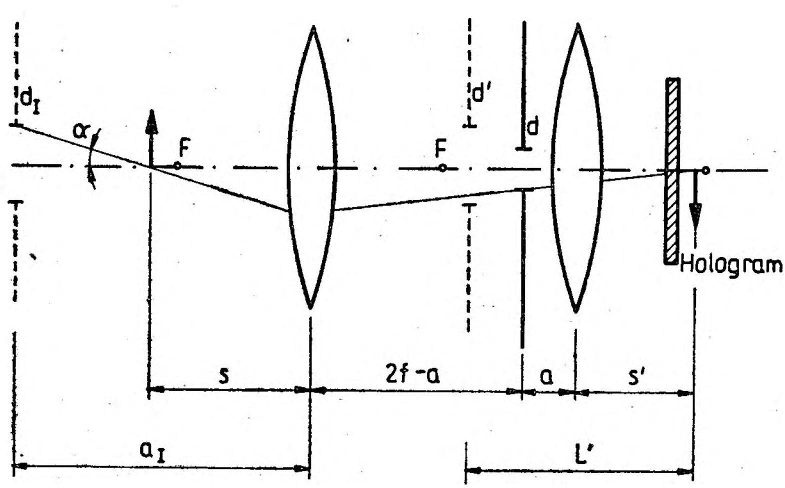

Fig. 3. Two-lens pseudoscopic system for rainbow holography

For the two-lens system we have

$$a = d'/2L' \tag{2}$$

where d' is diameter of the exit pupil, L' — distance between the image plane and exit pupil, and f — the focal length of lens.

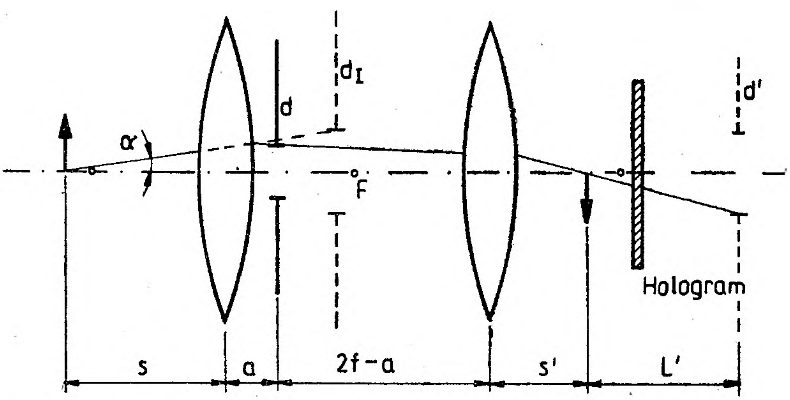

Fig. 4. Orthoscopic two-lens afocal system for rainbow holography

To compare the Equations (1) and (2) it is necessary to take $s = 2f$. In this case the aperture angle is obtained also from the expression

$$a = d'/2L'. \tag{3}$$

We see that the angle a depends only on diameter d' and distance L'. However, the distance between the image plane and exit pupil in pseudoscopic one-lens system cannot be chosen optionally. That is why the pseudoscopic images have the worse resolution. In the two-lens system L' can be optional.

3. Distance between the slit and imaging system

Let us consider now the parameter a, i.e., the distance between the slit and imaging system. For one-lens pseudoscopic arrangement this distance is represented by

$$a = f\frac{L'(s-f)-fs}{L'(s-f)-f^2}. \tag{4}$$

The variation of the parameter a is shown in Fig. 5.

The same equation, but for orthoscopic one-lens geometry, is as follows

$$a = f\frac{L'(s-f)+fs}{L'(s-f)+f^2}. \tag{5}$$

In this case the distance a as a function of s for two different parameters is presented in Fig. 6.

For two-lens system we have

$$a = f\frac{L'-2f+s}{L'-f+s} \tag{6}$$

in the pseudoscopic case (Fig. 7), and

$$a = f\frac{L'-s}{L'-s+f} \tag{7}$$

in orthoscopic geometry (Fig. 8).

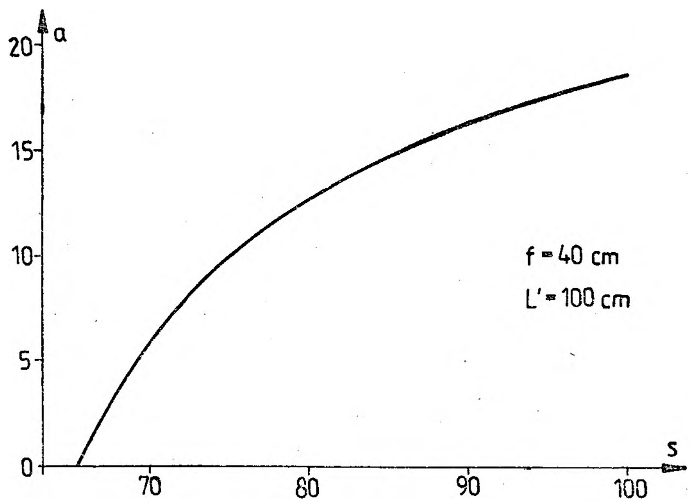

Fig. 5. Variation of parameter a for one-lens pseudoscopic system

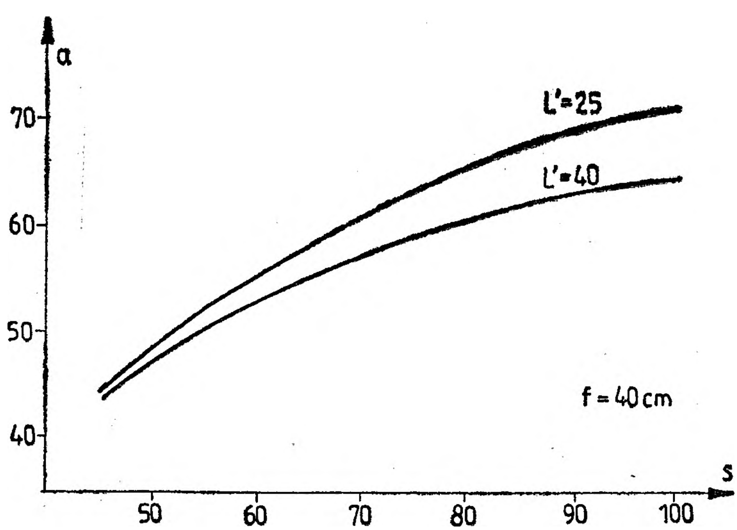

Fig. 6. Variation of parameter a for one-lens orthoscopic system

We cannot forget that in two-lens afocal system, by a we mean the distance either from the first lens (orthoscopic arrangement) or from the second lens (pseudoscopic geometry).

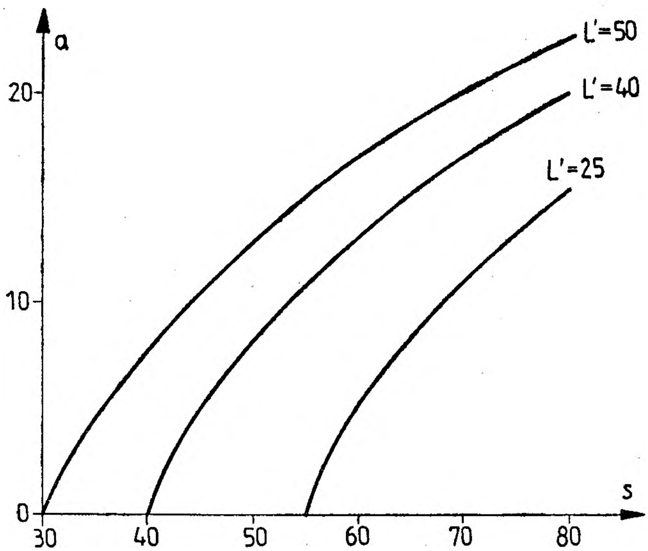

Fig. 7. Variation of parameter a for two-lens afocal pseudoscopic system

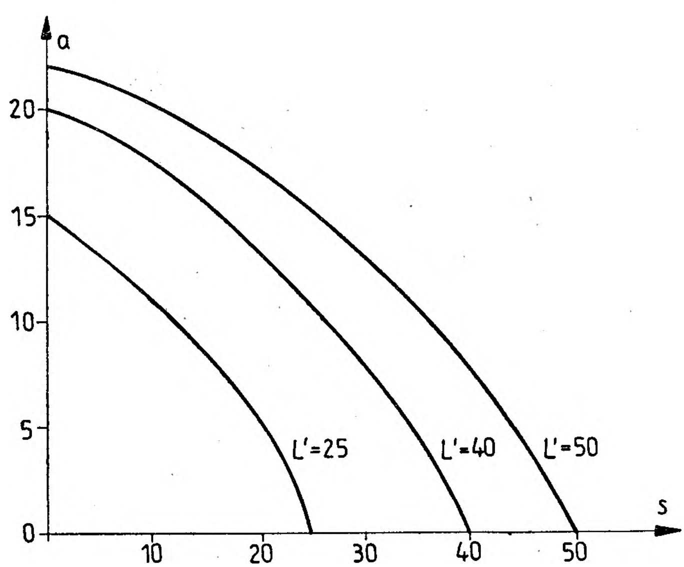

Fig. 8. Variation of parameter a in two-lens orthoscopic system

4. Vertical size of recorded objects

The narrow slit in optical system for rainbow holography limits the object beams coming from the object plane to the lens. In this way a vertical field of view is restricted.

The following expressions describe the maximal size of vertical objects for pseudo- and orthoscopic one-lens systems and for pseudo- and orthoscopic two-lens system

$$H \leqslant \frac{D}{2f} \frac{L'(s-f)^2}{L'(s-f)-sf}, \tag{8}$$

$$H \leqslant \frac{D}{2f} \frac{L'(s-f)^2}{L'(s-f)+fs}, \tag{9}$$

$$H \leqslant \frac{D}{2} \frac{L'}{L'+s}, \tag{10}$$

$$H \leqslant \frac{D}{2} \frac{L'}{L'-s+2f} \tag{11}$$

where D is a diameter of imaging lens.

We have shown that our system (two-lens afocal system) offers the best results in orthoscopic case.

5. Conclusions

We have presented the one-lens and two-lens optical systems for pseudo- and orthoscopic rainbow holography. Comparing some geometrical parameters of these systems we can easily notice the advantages of afocal system.

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