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DESIGN AND ANALYSIS OF KAPLERIAN TELESCOPE USING ZEMAX SOFTWARE PROGRAM

Noor L.Hussien* Marwa K.Mustafa, Hadeel M. Rasheed, Haider Y. Hammod
* Ministry of Science and Technology

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ABSTRACT

Using software Zemax to design and analysis of Kaplerians telescope by choosing the best parameters design of this visual system represented dimension focal length lenses used and which determine the right size for clarity of target and did not notice any influence on the rest of the parameters of thick lens diameter and radius. It was observed a significant effect of the materials involved in the manufacture of these optical components to this change.

KEYWORDS: Zemax , Kaplerians telescope, lens.

INTRODUCTION

A simple a focal lens can be made up of two focusing lenses , an objective and an eyepiece, set up so that the rear focal point of the objective coincides with the front focal point of the eyepiece . There are two general classes of simple a focal lenses , one in which both focusing lenses are positive , and the other in which one of the two is negative . A focal lenses containing two positive lenses were first described by Johannes Kepler in Dioptric**,** in 1611 , 4 and are called keplerian . Lenses containing a negative eyepiece are called Galilean , and will be discussed separately . Generally , a focal lenses contain at least two powered KE Thin-Lens Model of a Keplerian A focal Lens Figure 1 shows a thin-lens model of a keplerian telescope . The focal length of its objective is f o and the focal length of its eyepiece is f e . Its properties can be understood by tracing two rays , ray 1 entering the objective parallel to the optical axis , and ray 2 passing through F/o the front focal point of the objective .

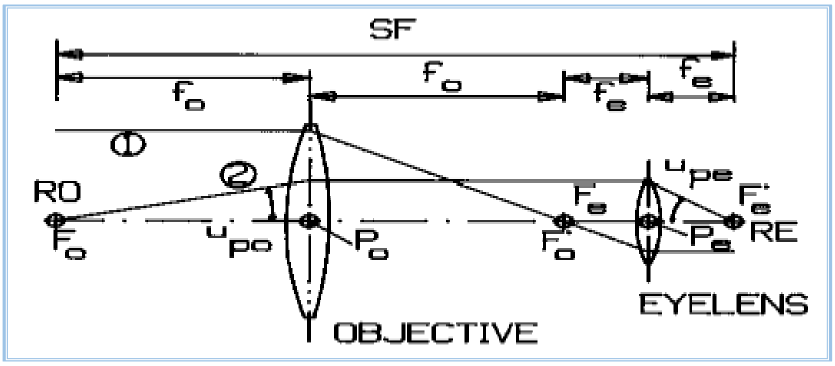

Figure1:Thin-lens model of keplerian a focal lens

F o , the front focal point of the objective . Ray 1 leads directly to the linear magnification m , and ray 2 to the angular magnification M :

$$M=\frac{-f0}{fe} \quad ;M=-\frac{f0}{fe}=\frac{\tan_{pe}^{u}}{\tan_{po}^{u}} \tag{1}$$

Equation (1) makes the relationship of a focal magnification to the Scheimpflug rule more explicit , with focal lengths f o and f e substituting for s a and s/ a. The second ray shows that placing the reference point R0 at F o will result in the reference point RE falling on F / e , the rear focal point of the eyepiece . The reference point separation for R0 in this location is

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SF=2fe+2f0=2(1-M) f e =2(1-m)f0 (2)

One additional generalization can be drawn from Fig . 1 : the ray passing through F o will emerge from the objective parallel to the optical axis . It will therefore also pass through F /e even if the spacing between objective and eyepiece is increased to focus on nearby objects . Thus the angular magnification remains invariant , if up o is measured from F o and u p e is measured from F /e, even when adjusting the eyepiece to focus on nearby objects makes the lens system depart from being strictly a focal . The simple thin-lens model of the keplerian telescope can be extended to systems composed of two real focusing lenses if we know their focal lengths and the location of each lens' front and rear focal points . Equation (1) can be used to derive M , and SF can be measured [2].

EYE RELIEF MANIPULATION

The earliest application of keplerian a focal lenses was to obtain magnified views of distant objects . To view distant objects , the eye is placed at RE . An important design consideration in such instruments is to move RE far enough away from the last surface of the eyepiece for comfortable viewing . The distance from the last optical surface to the exit pupil at RE is called the eye relief ER . One way to increase eye relief ER is to move the entrance pupil at RO toward the objective . Most telescopes and binoculars have the system stop at the first surface of the objective , coincident with the entrance pupil , as shown in Fig . 2 a [3] .

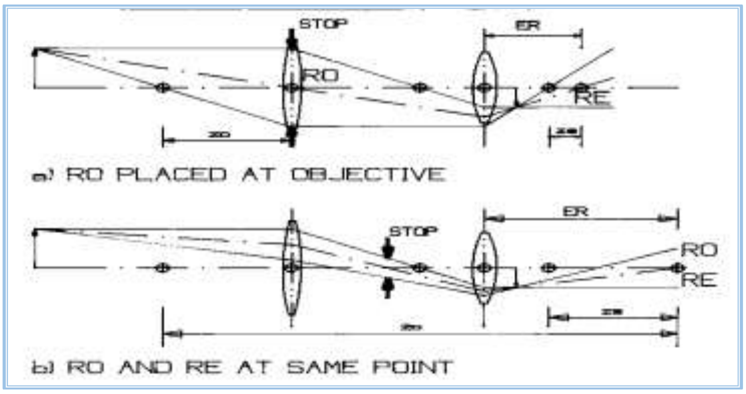

Figure2: Increasing eye relief ER by moving stop

APPLICATIONS OF BEAM EXPANDERS

Beam expanders are frequently used in combination with gas or solid state lasers in order to expand the existing beam to the extent desired. In some applications, however, the reduction of the beam divergence may be more important. With a correspondingly designed beam expander it is also possible to obtain focusing, temperature compensation and - with a modified construction - also shape changes of the beam bundle cross-section in an optical system. One particular important application is with laser scanners which work with an He Ne laser as the beam source (Figure 3-1). [4] The beam bundle of the laser is expanded by a beam expander, then deflected (e.g. by a polygon wheel or a galvo mirror) and focused on the image (scan) plane with one or more lenses. Here, the expansion is used to fill up the entrance of the focusing lens as completely as possible with the beam bundle to minimize diffraction and to obtain the best point image quality. If laser diodes are used as beam source in the optical system, beam expanders will generally be positioned behind a collimator which will give a parallel orientation to the divergent exit bundle of the laser diode. For high quality demands, the collimator may contain correction elements, e.g. to eliminate laser diode astigmatism, to approximate an elliptical bundle cross-section to a circular shape, for temperature correction or for system coordination. However, it is also possible to integrate correction elements in the beam expander[5]. If beam expanders with a variable expansion factor are used in optical systems for laser material working (or engraving), a change in the bundle cross-section in front of the pupil of the focusing lens can be used to control the heat requirement to adapt this to the material to be worked. When used in combination with high power lasers, a further advantage of bundle cross-section expansion can be found in the lower thermal strain on the following optical system[6].

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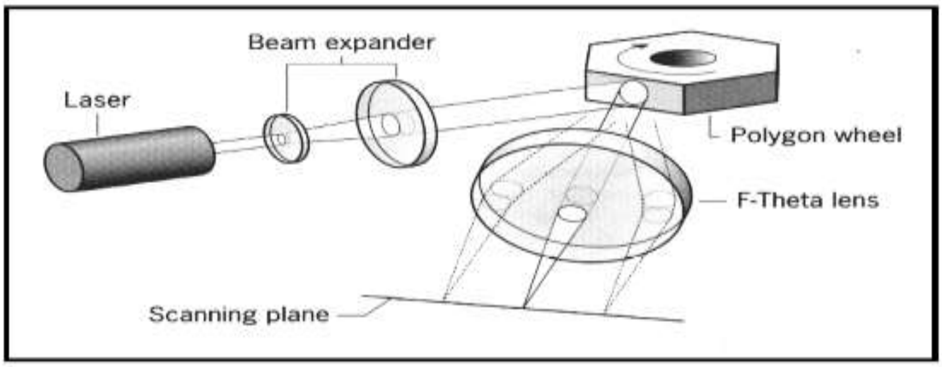
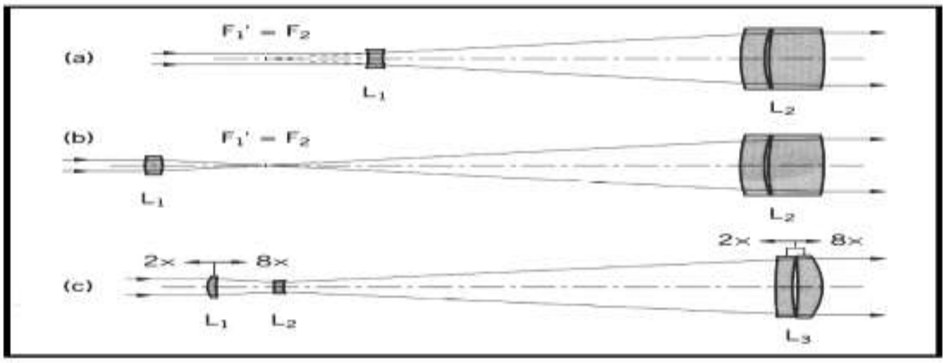


Figure (3): Beam expander in schematic beam path of a laser scanner with an He Ne laser as the beam source

Due to the scanner with an He Ne expansion of the beam bundle cross-section the entrance pupil of the F-Theta lens is optimally filled up. Due to the reduced diffraction and less beam divergence this causes, a smaller point image diameter and so a better image quality can be achieved in the scanning plane[7].



Figure(4): Design of a beam expander

This figure according to the principle of Galileo (a) and of the Kepler telescope (b)[8]. The Galilean principle produces a shorter over-all length and is therefore more popular. Kepler's principle inverts the image and provides a real focal point F1'-which needs to be taken into account for some applications. The various beam expanders from Cascade Laser (c) largely correspond to the Galilean principle, but from the first to the second lens element they do have a convergent beam path as the Kepler's principle [9].

The results: ***Table(1) Bk7 telescope design***

Surf	Type	Comment	Radius	Thickness	Glass	Semi-Diameter	
OBJ	Standard		Infinity	Infinity		0.000	
STO	Standard		Infinity	10.000		0.500	U
2*	Standard	KBX022	11.000	6.000	BK7	6.300	U
3*	Standard		-11.800	125.000		6.300	U
4*	Standard	KPX229	95.000	10.000	BK7	38.100	U
5*	Standard		Infinity	10.000		38.100	U
IMA	Standard		Infinity	-		7.800	U

This table consist of five surfaces, radius and thickness, the type of metal of lens which is used is Bk7 so that all the input data above we can see the results of the design as in below.

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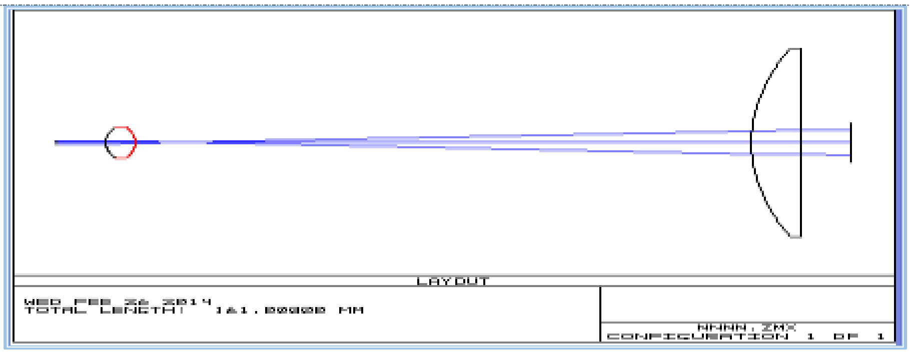
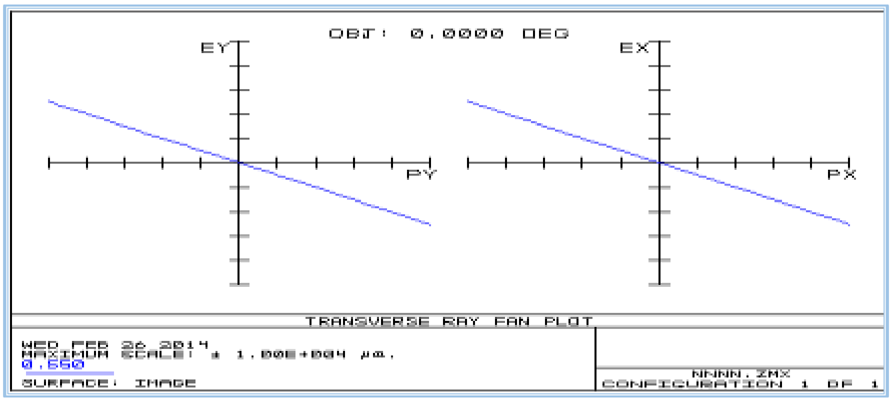
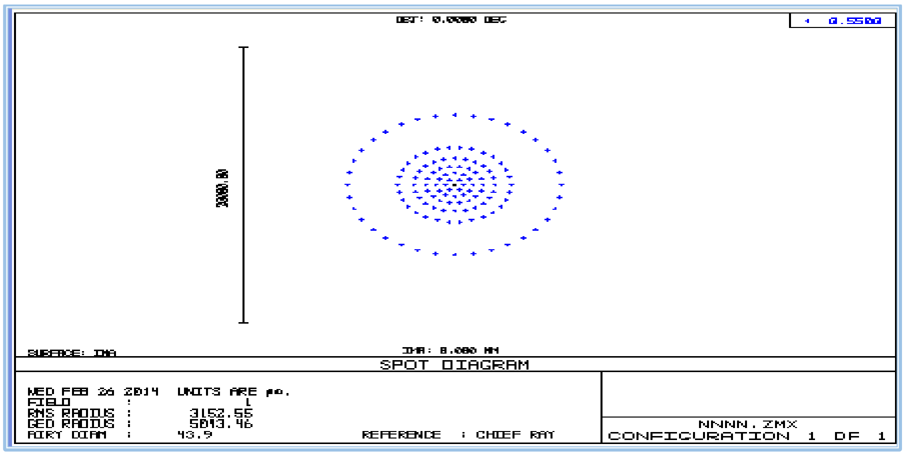


Figure(5) the lens structure of the telescope



Figure(6) the transverse ray fan plot

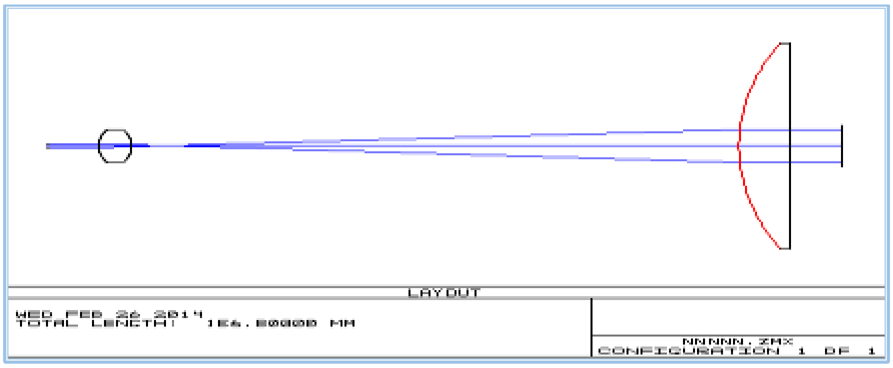


Figure(7) spot size diagram

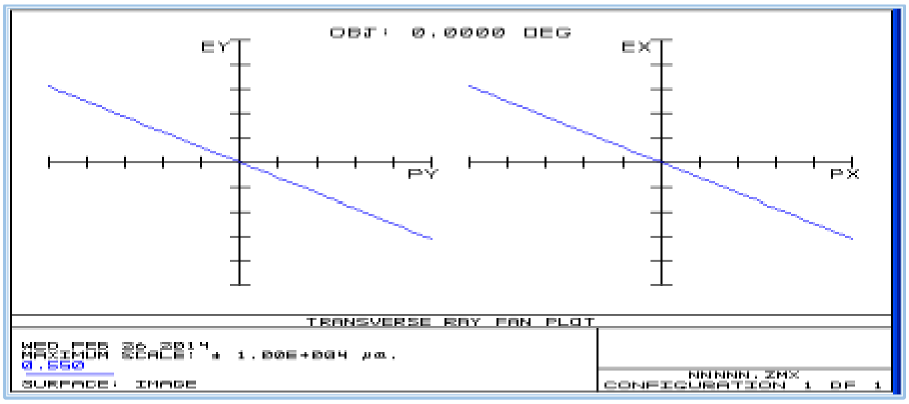
Table(2) SF1 telescope design

Surf:Type		Comment	Radius		Thickness		Glass		Semi-Diameter	
OBJ	Standard		Infinity		Infinity				0.000	
STO	Standard		Infinity		10.000				0.500	U
2*	Standard	KBX022	11.800		6.600		SF1		6.300	U
3*	Standard		-11.800		125.000				6.300	U
4*	Standard	KPX229	95.000		10.200		SF1		38.100	U
5*	Standard		Infinity		10.000				38.100	U
IMA	Standard		Infinity		-				7.800	U

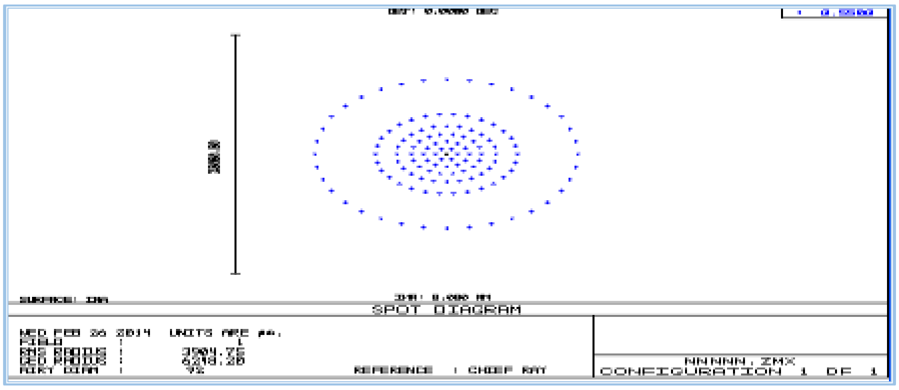
This table consist of five surfaces, radius and thickness, the type of metal of lens which is used is SF1 so that all the input data above we can see the results of the design as in below.



Figure(8) the lens structure of the telescope



Figure(9) the transverse ray fan plot



Figure(10) spot size diagram

DISCUSSION

For the a above results we can see that the aberration for the design lenses of telescope can be represents by the figures in each design consider the ray intercept curves in figure(2) shows that transverse ray aberration of rays from an axial object point.in this plot we have introduced two new terms(p y)and (p x) stands for "tangential section" which refers to the section of the pupil in which the x-coordinates are zero. I .e in the meridian plan ,"s" is the sagittal section .this figure . shows the tangential and sagittal section varies with each other in the same time .figure(4) shows the spot size of (BK7)design has aberration less than (SF1) design. the variation of the effective focal length and spot size diagrams .So that we made two design to explain this point , the value of (EFF) OF (Bk7) design(32) and (SF1)designee is (89).

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