

## (9) Optical Aberrations

### 光學像差

Translation: J D White

#### 1. Purpose

To observe various aberration. To understand the causes of aberrations

#### 2. Experimental Principle

Under the assumption of ideal Gaussian optics, spherical waves emitted at a any point in space, after refraction through the optical system, can converge to a single point in space. IN this case the system is said to be aberration free. However, in any real system aberrations are present. Aberrations fall into two classes: monochromatic and chromatic. Monochromatic aberrations are caused by the geometry of the lens and occur both when light is reflected and when it is refracted. They appear even when using monochromatic light, hence the name.

In 1857, Seidel(1821-1896) wrote a mathematical description of monochromatic aberrations in which he divided aberrations into five (5) different types:

$$a(Q) = {}_0C_{40}r^4 + {}_1C_{31}h'r^3 \cos\theta + {}_2C_{22}h'^2r^2 \cos^2\theta + {}_2C_{20}h'^2r^2 + {}_3C_{11}h'^3r \cos\theta$$

from the terms in this equation, we have...

$r^4$	球面像差	spherical aberration
$h' r^3 \cos(\theta)$	彗星像差	coma
$h'^2 r^2 \cos^2(\theta)$	像散	astigmatism
$h'^2 r^2$	光場彎曲	field curvature
$h'^3 r \cos(\theta)$	扭曲(畸變)	Image distortion

Chromatic aberrations are caused by dispersion, the variation of a lens's refractive index with wavelength. They do not appear when monochromatic light is used. There are two types of chromatic aberrations: (1) axial or longitudinal and (2) lateral or transverse

The key point in this experiment is to observe three kinds of aberration and understand the sources

#### 3. 實驗儀器 (Equipment)

HeNe Laser and support (HeNe), Turning Mirror (TM) , Fixed Aperatures (FA,2x), Convex Lens (telephoto and short focal length), Acrylic Sheets (4) , Screen (1)

#### 4. 實驗步驟 Procedure

4.1 光的準直 Collimation of Light

4.2 空間濾波器 Spatial filter

4.3 像差觀察 Observing Aberrations

## 5. 【實驗記錄】 Results

**Table 1: Spherical Aberrations 球面像差**

Focal Position	No Obstruction [cm]	Center Block [cm]	Aperature [cm]
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
平均			

**Table 2: Coma 彗星像差**

Rotate Left		Rotate Right		
				At Focal point
				Out side focal point

**Table 3: Image Distortion 扭曲(畸變)**

Pincushion Distortion		Barrel Distortion	