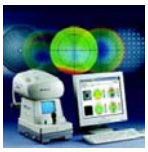
Ögats optik, föreläsning 11

Mätning av ögats bildkvalitet

Del 2: Vågfrontsmätning

Vågfrontsmätare

Tscherning aberroskop



Hartmann-Shack vågfrontssensor

Retinoskopi

Hartmann-Shack vågfrontssensor

Hartmann-Shack vågfrontssensor

Hartmann-Shack vågfrontssensor

Laser ray-tracing

Vågfrontsmätning: Hartmann-Shack

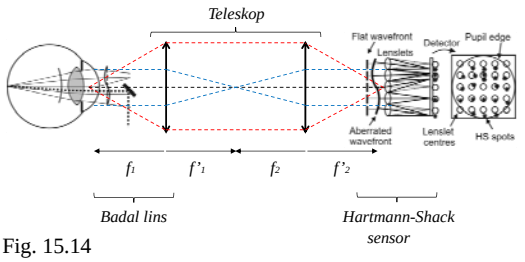
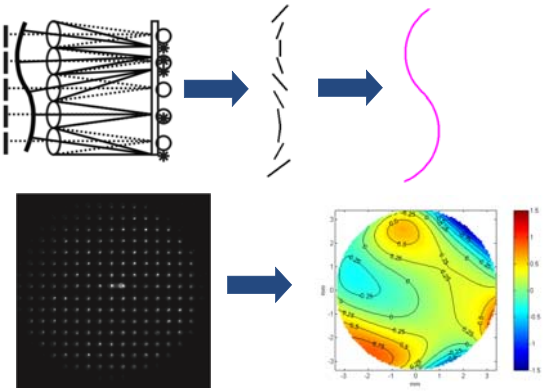
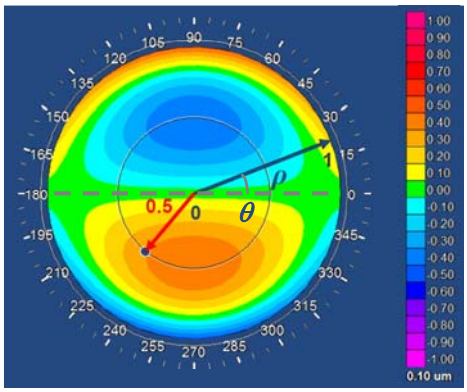


Fig. 15.14

Vågfrontsmätning: Hartmann-Shack



Beskriva vågfronter matematiskt



Zernikepolynom = standard vågfronter

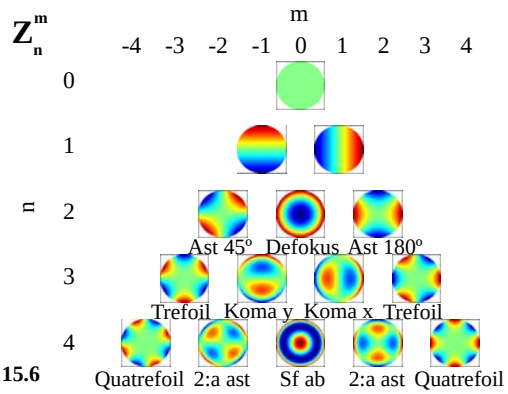
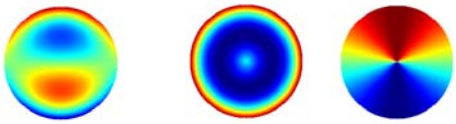


Table 15.6

Zernikepolynom = standard vågfronter

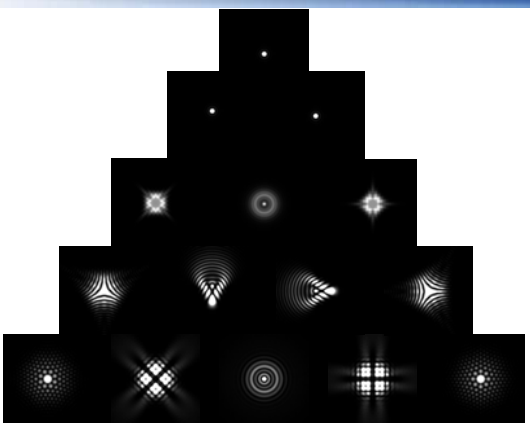
$$Z_n^m(\rho,\theta) = N(\rho^n + \ldots) \times \begin{cases} \cos(m\theta) \\ \sin(m\theta) \end{cases}$$

Zernike-polynom | Radiellt polynom | Vinkel-funktion

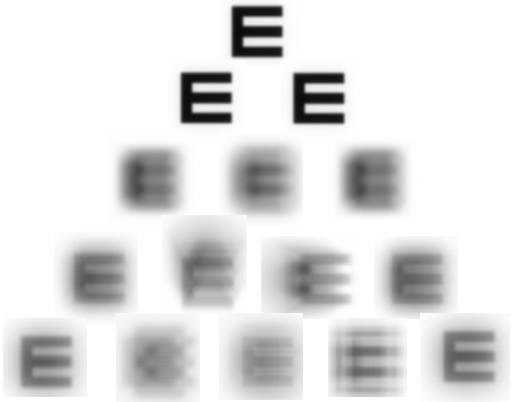


"Methods for Reporting Optical Aberrations of Eyes" American National Standard: ***Z80.28-2004***

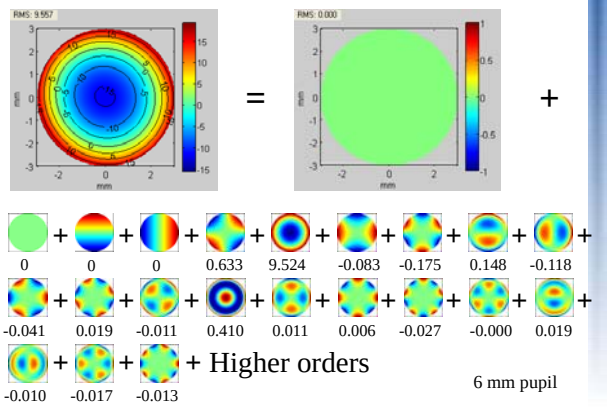
Zernikepolynom – effekt på PSF



Zernikepolynom – effekt på bokstav



Zernikekoefficienter



Zernikekoefficienter

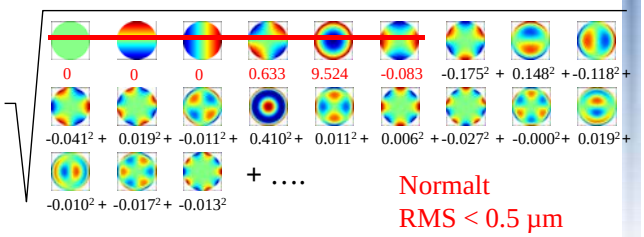
$$\underbrace{W(\rho,\theta)}_{\text{Vågfront}} = \sum_{n,m} \underbrace{c_n^m Z_n^m(\rho,\theta)}_{\text{Zernike-polynom}}$$

Zernikekoefficienter (mäts i mikrometer)

Pupillberoende!

Root-Mean-Square värde

Higher Order RMS =



= 0.5 µm (6 mm pupil)

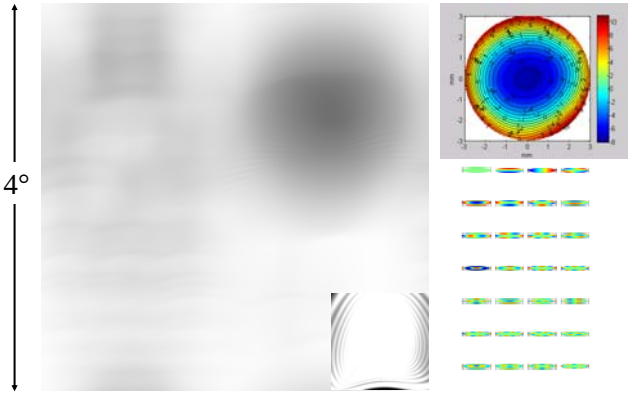
Normalt RMS < 0.5 µm vid 6 mm pupill

Vågfrontsrecept

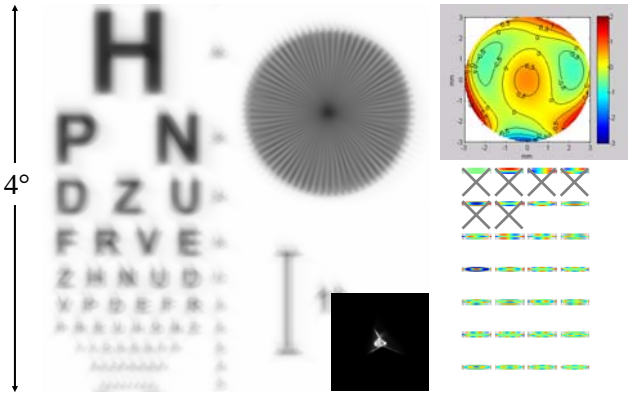
Pupillberoende!

Mode	c [µm]	c [µm]	Benämning
Z_2^{-2}	0.4557	0.1281	Astigmatism 45°
Z_2^0	4.4954	1.2563	Defokus
Z_2^2	-0.2884	-0.1318	Astigmatism 180°
Z_3^{-3}	-0.0252	-0.0133	Vertikal trefoil
Z_3^{-1}	-0.0379	0.0048	Vertikal koma
Z_3^1	-0.0414	0.0015	Horisontell koma
Z_3^3	0.0571	0.0151	Sned trefoil
Z_4^{-4}	-0.0115	-0.0021	Quatrefoil
Z_4^{-2}	0.0106	0.0024	Sekundär ast
Z_4^0	0.1690	0.0125	Sfärisk aberration
Z_4^2	0.0365	0.0082	Sekundär ast
Z_4^4	0.0246	-0.0015	Quatrefoil
Analysdiameter	5.402 mm	3.000 mm	
Total RMS	4.532 µm	1.270 µm	
Högre ordn. RMS	0.198 µm	0.026 µm	
3:e ordn. RMS	0.084 µm	0.021 µm	
4:e ordn. RMS	0.175 µm	0.015 µm	

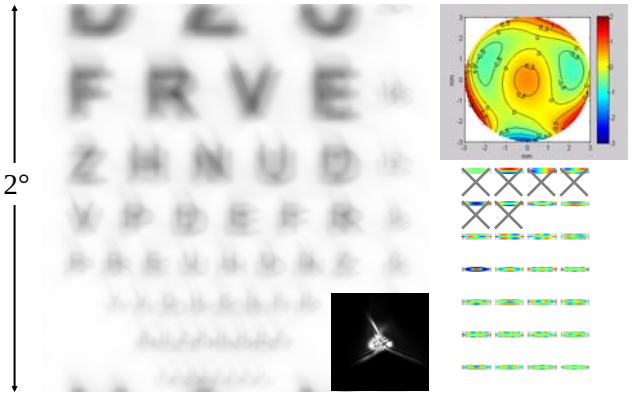
Okorr. öga (-3, -0.75, 10°, 6 mm pupill, RMS = 0.5 µm)



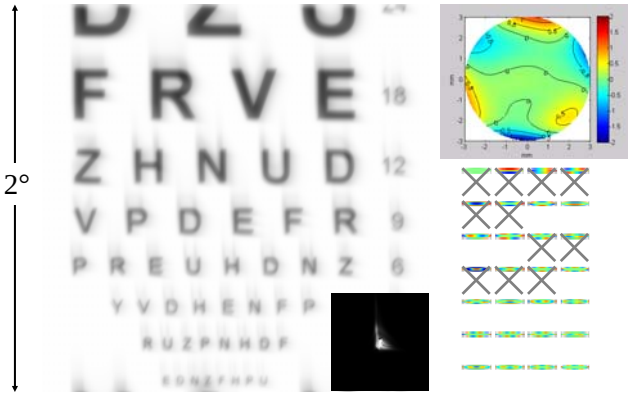
Sfär +cyl korrektion



Sfär +cyl korrektion



Sf+cyl+sf ab korrektion



Bildkvalitet: Aberrationer

För vilken pupillstorlek ser de flesta bäst?

- 1 mm pupill
- 3 mm pupill
- 5 mm pupill
- 7 mm pupill

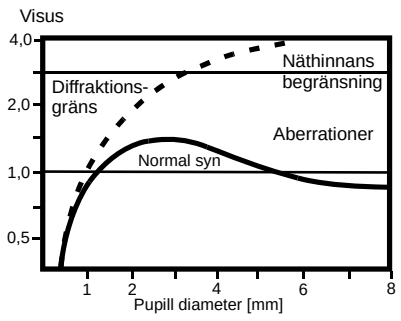


Fig. 3.6