

3. VIAOPTIC Technologie-Tag 17.10.2007 in Wetzlar

Optische Messtechnik für Asphären

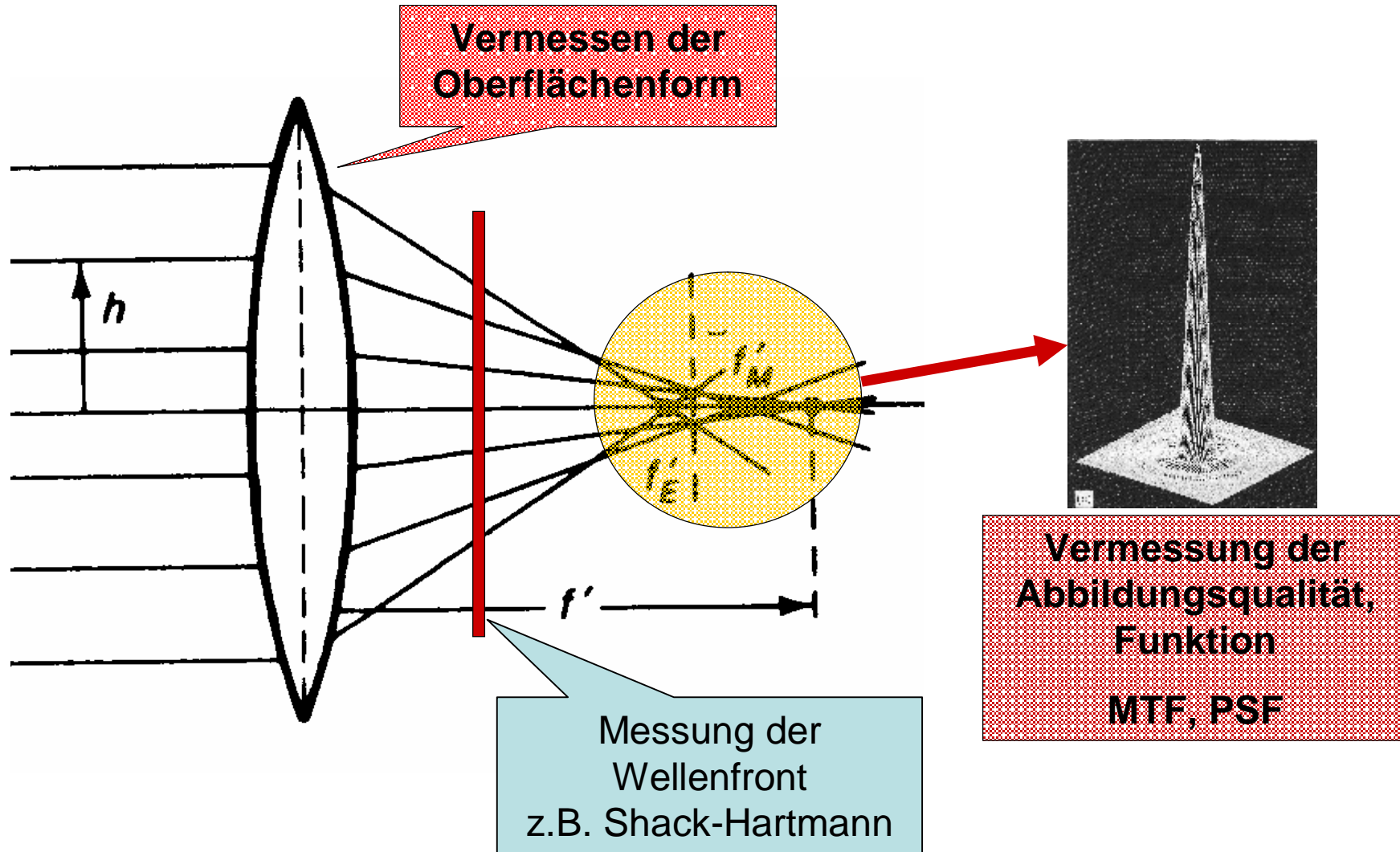
Theo Tschudi

Photonik Zentrum Hessen in Wetzlar AG

Inhalt

- Problemstellung
- Interferometrische Messungen
- Abtastende Verfahren
- Einige wichtige Probleme und Lösungsansätze
- Freiformflächen

Form- / Funktionsprüfung

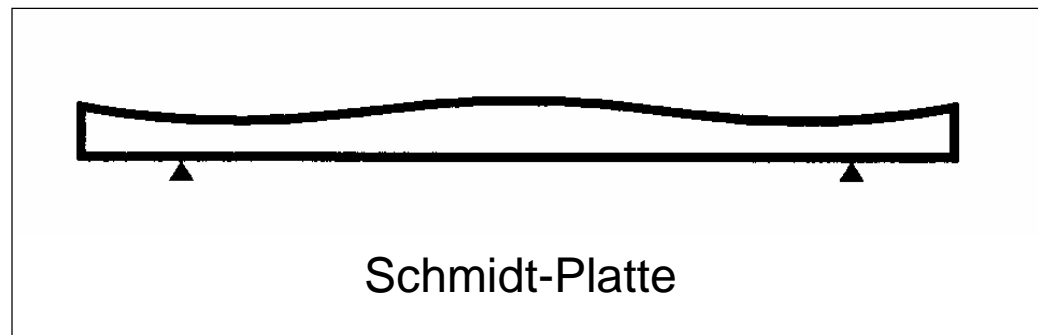
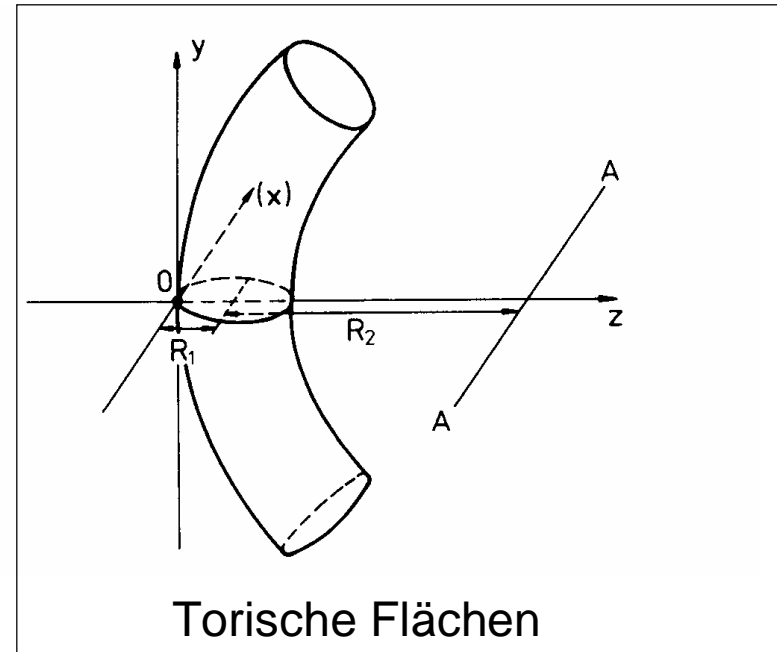
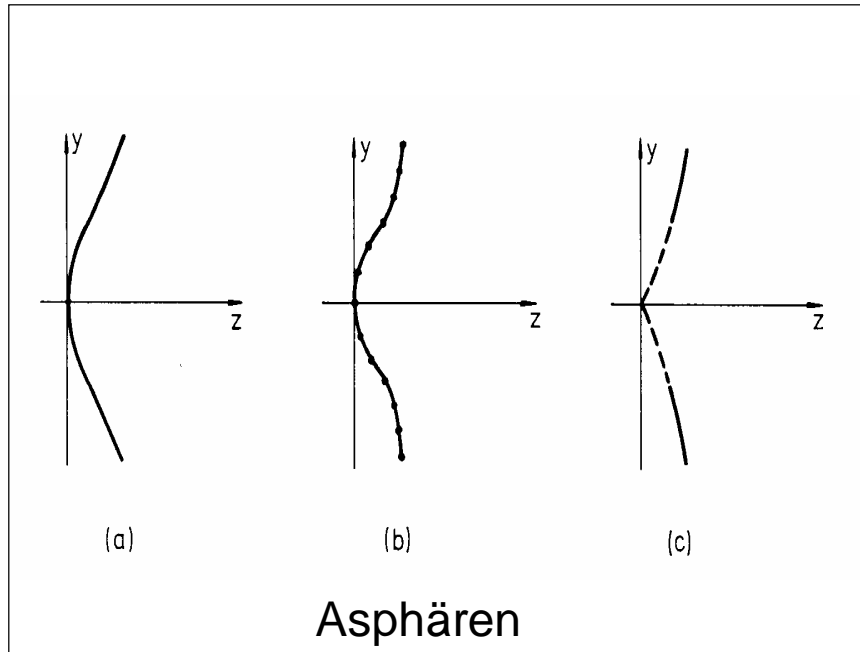


Anforderungen an optische Komponenten

Grösse von Elementen:	sub-mm bis einige 10 cm
Formtreue:	$\lambda/20$ bis $\lambda/100$; d.h. bei $\lambda = 633$ nm 30...5 nm
Oberflächenqualität:	kleinste Streuung (ppm)
Messgenauigkeit:	nm
Messbereich:	bis cm (z.B. Abweichung von Sphäre)
Messgeschwindigkeit:	~ Produktionszeit
Probleme:	Unschärferelation, Phasenzelle

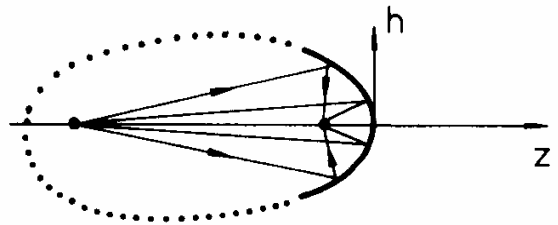
$$\Delta x \Delta y \Delta z \approx h^3$$

Asphärische Flächen

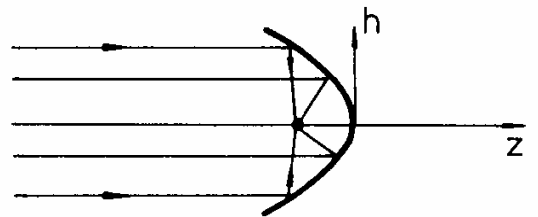


Nichtsphärische Flächen

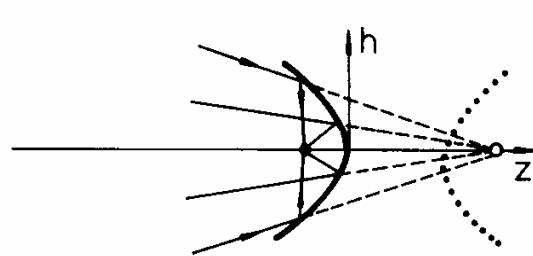
REFLECTING



.... ELLIPSOID

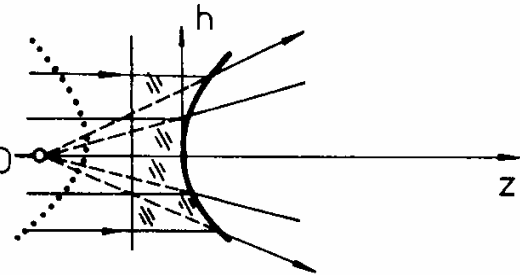
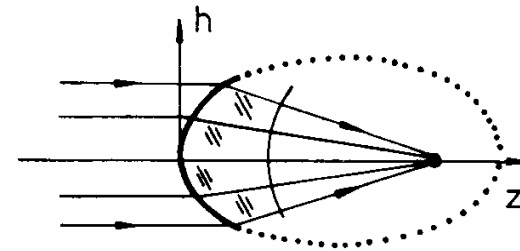


.... PARABOLOID

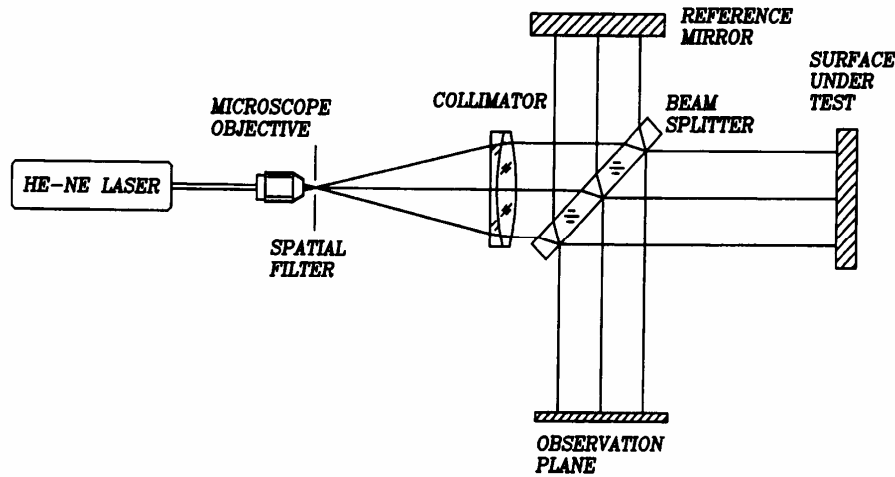


.... HYPERBOLOID

REFRACTING

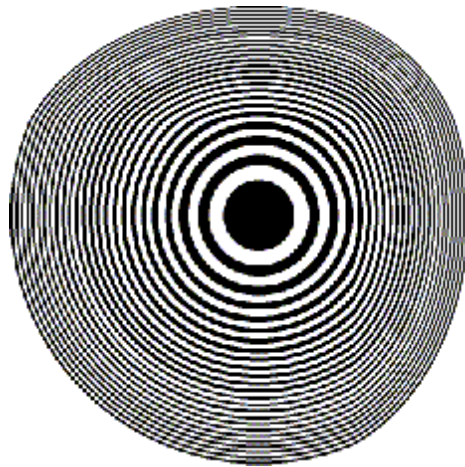


Interferometrie



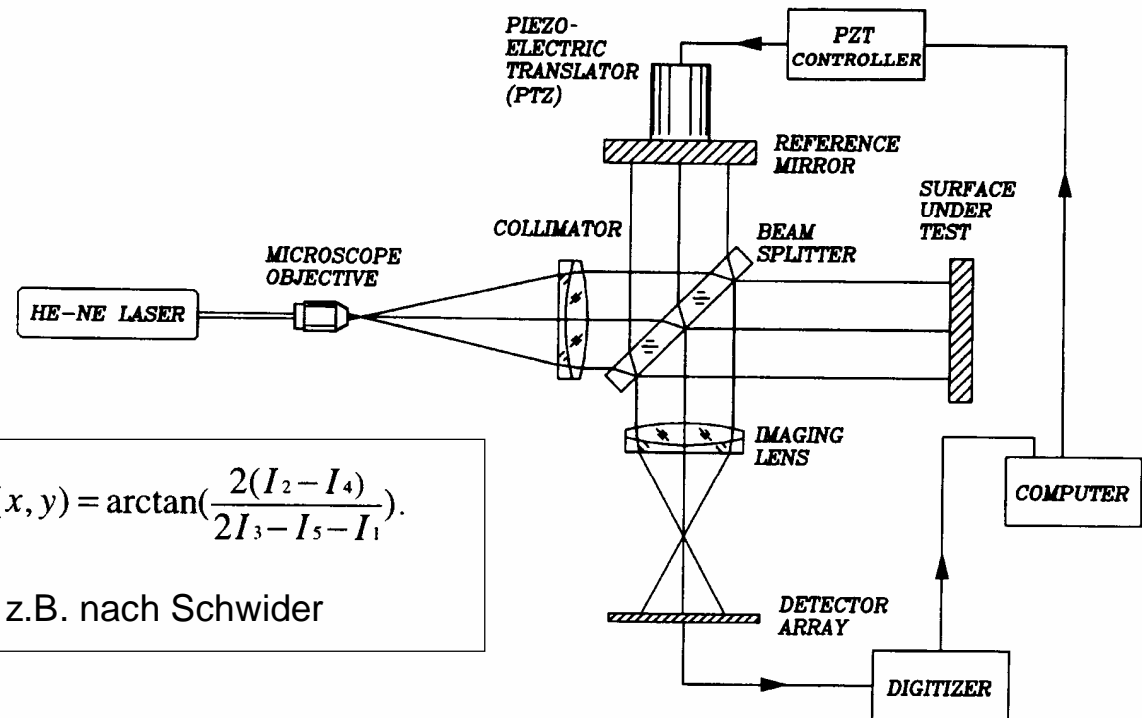
Schema des Twyman-Green Interferometers

With phase shifting transducer

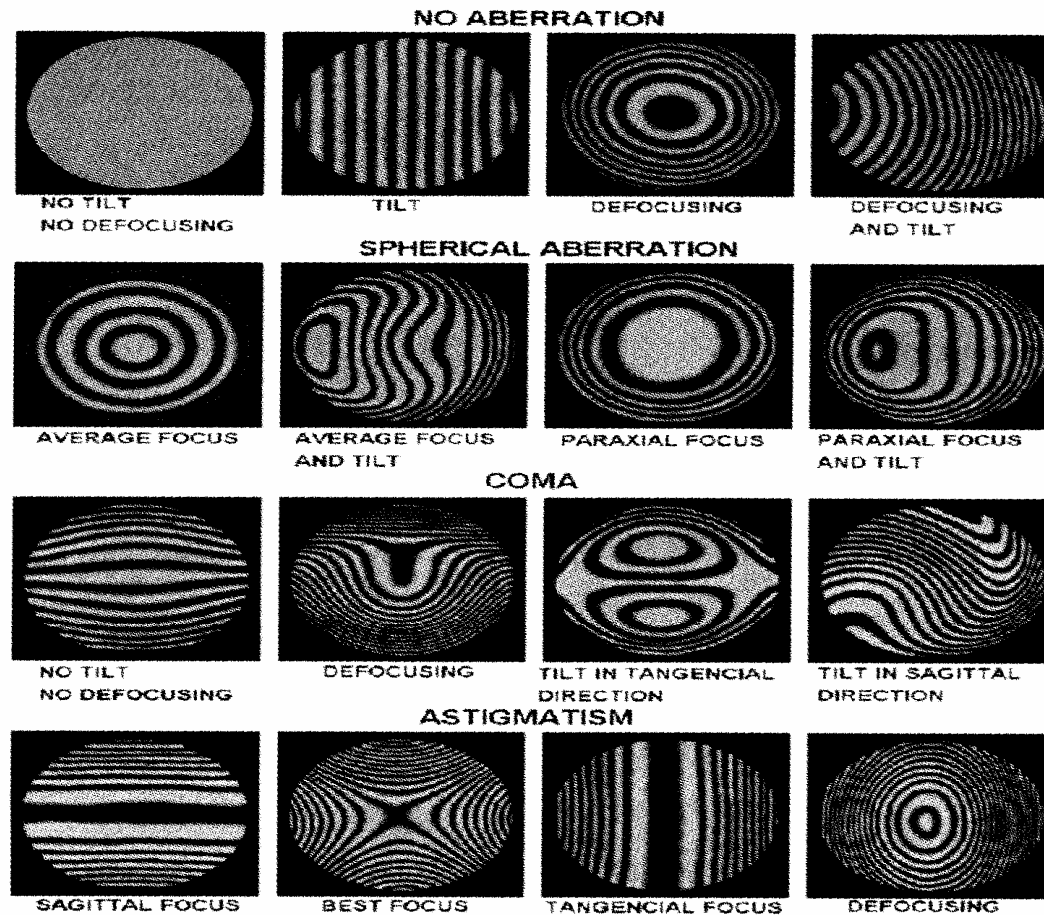


$$\Phi(x, y) = \arctan\left(\frac{2(I_2 - I_4)}{2I_3 - I_5 - I_1}\right)$$

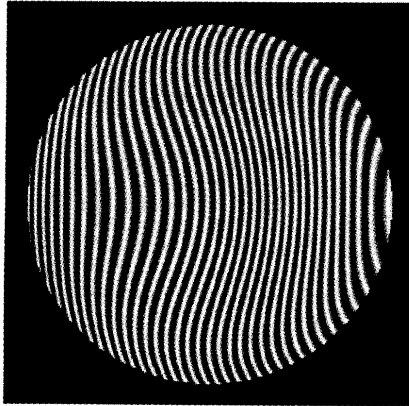
z.B. nach Schwider



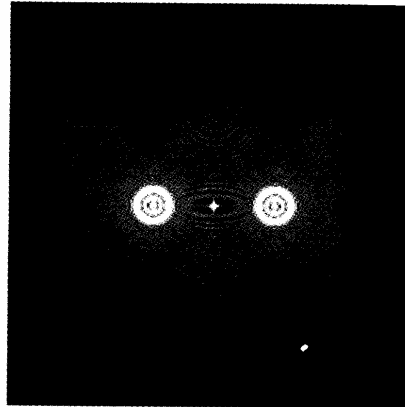
Twyman-Green Interferogramme



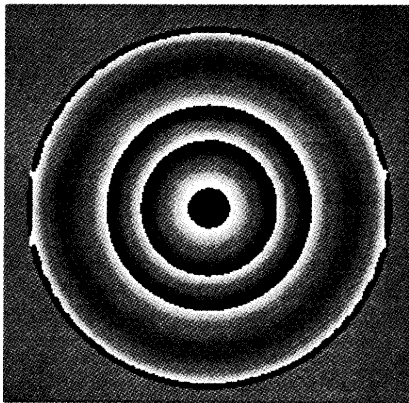
Phasenauswertung



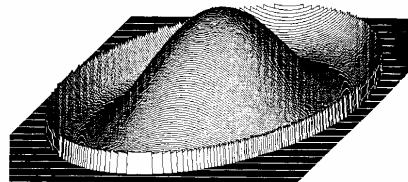
a



b



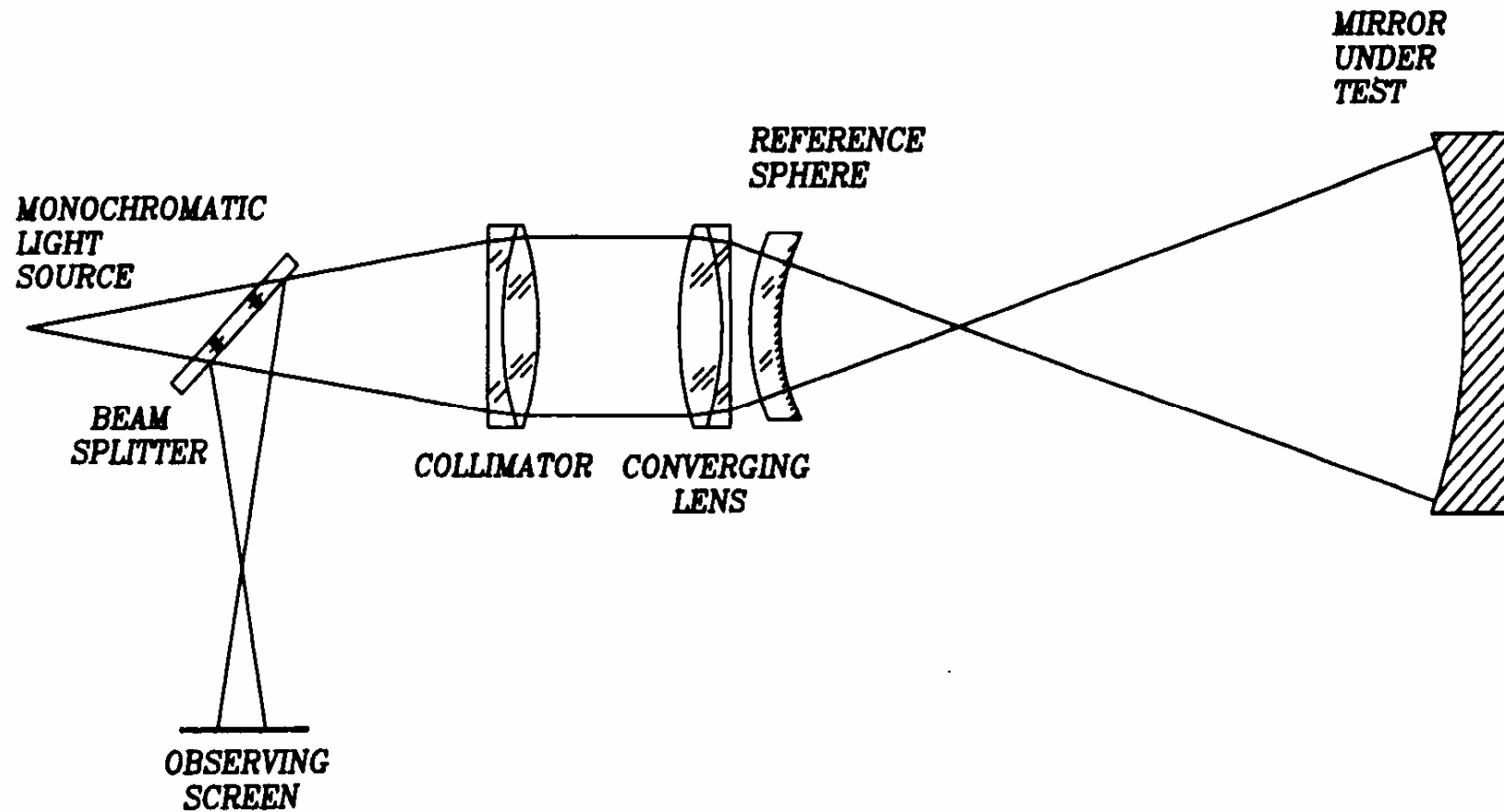
c



d

Phase demodulation with linear carrier. a) interferogram, b) Fourier Transform of interferogram, c) wrapped phase, d) unwrapped phase

Fizeau Interferometer zur Kontrolle konkaver sphärischer Flächen mit Benutzung einer konkaven Referenzfläche



Messung von asphärischen und Freiformflächen

Anwendung Asphären

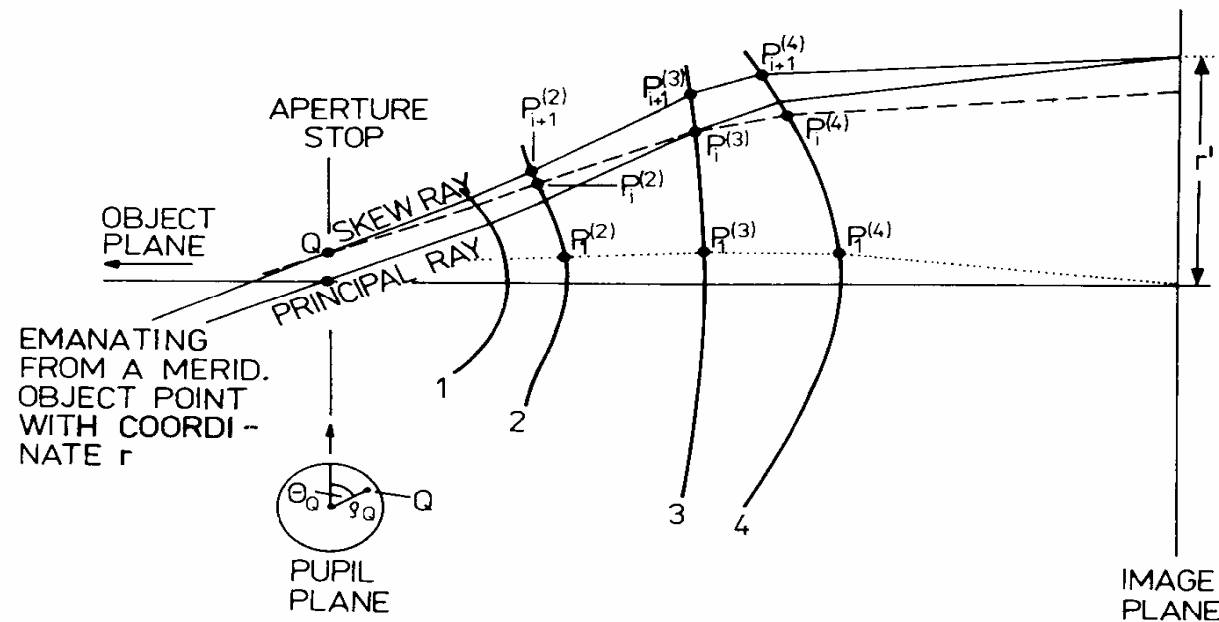


Fig. 19. Designing three aspherics (2, 3, 4) of an optical system free from distortion, field curvature, and astigmatism. The near-axis region (bounded by the dotted line) and the spherical surface 1 have been determined by precalculations. The system consists of two single lenses (1, 2) and (3, 4) in air. The distance between the principal ray and the neighboring skew ray has been exaggerated in the figure. The points P lie in the meridional plane and are nodes according to fig. 2b (see § 2.1).

Anwendung Asphären

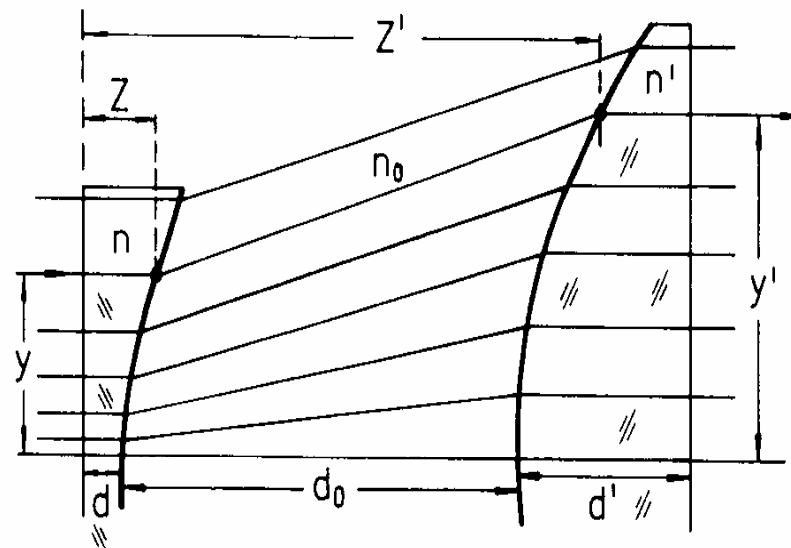
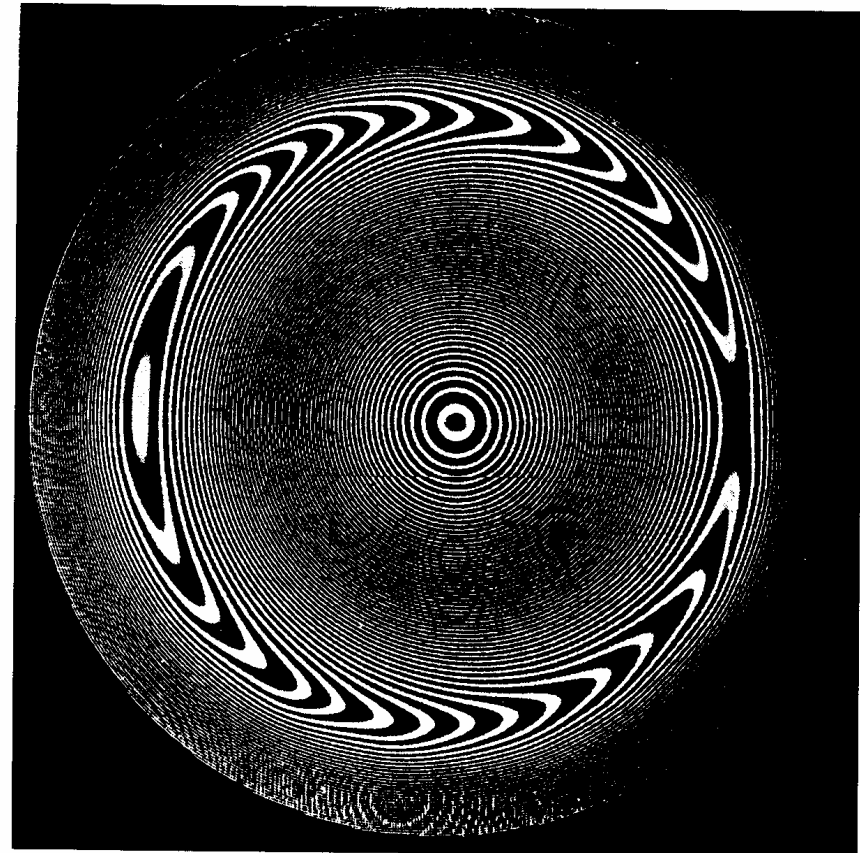
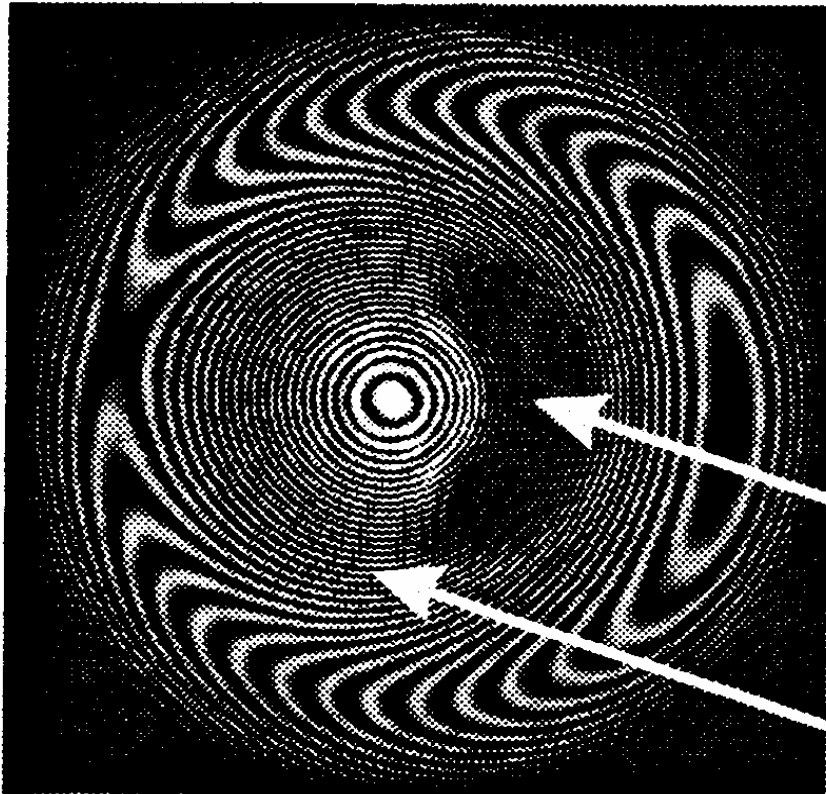


Fig. 15. System of two plano-aspheric lenses, which converts a parallel bundle with a given axisymmetrical intensity distribution into a parallel bundle with uniform intensity distribution over a given diameter. The two aspherics separate the three media of the refractive indices n , n_0 , and n' , respectively.

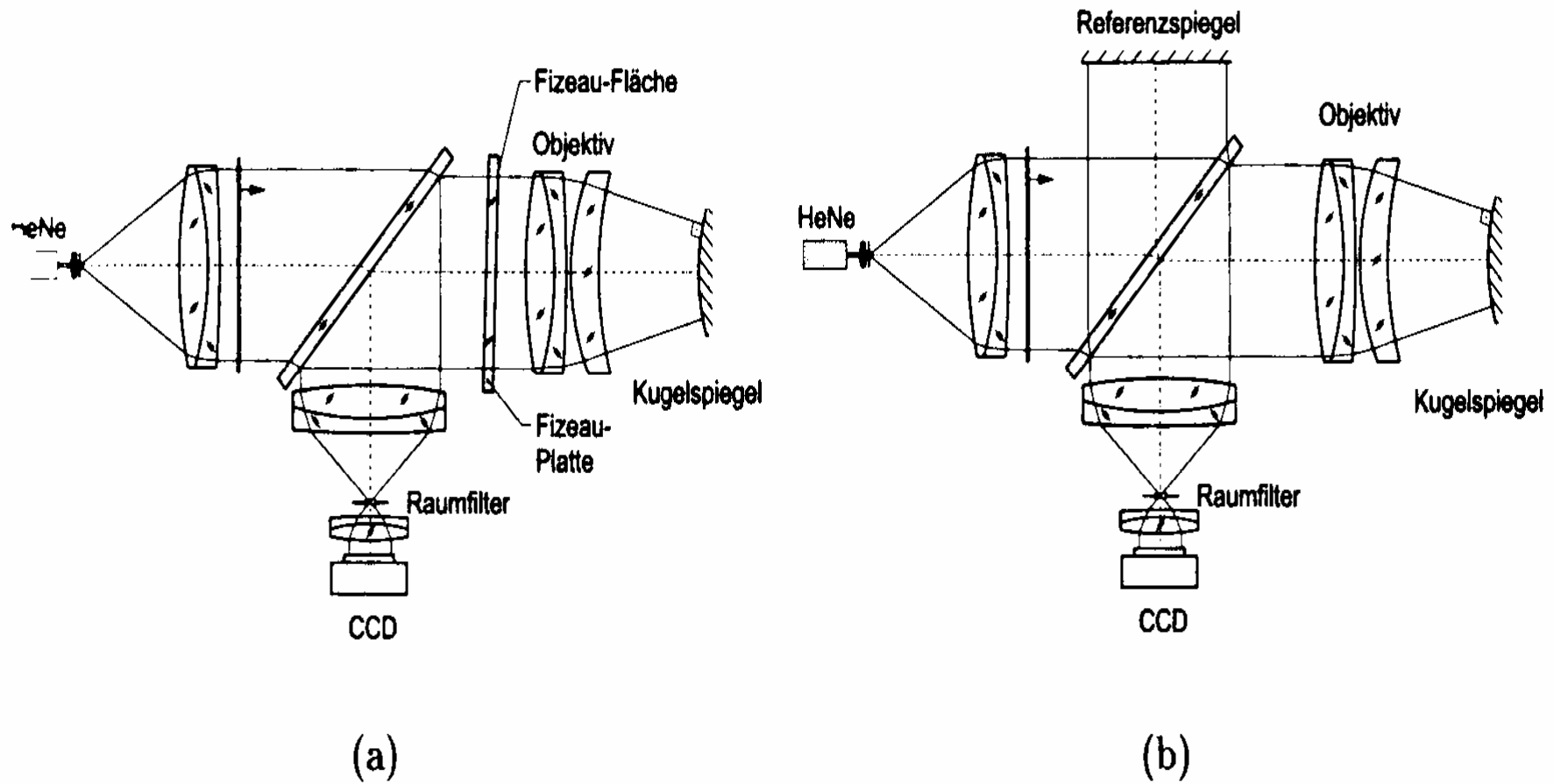
Interferogramme von Asphären

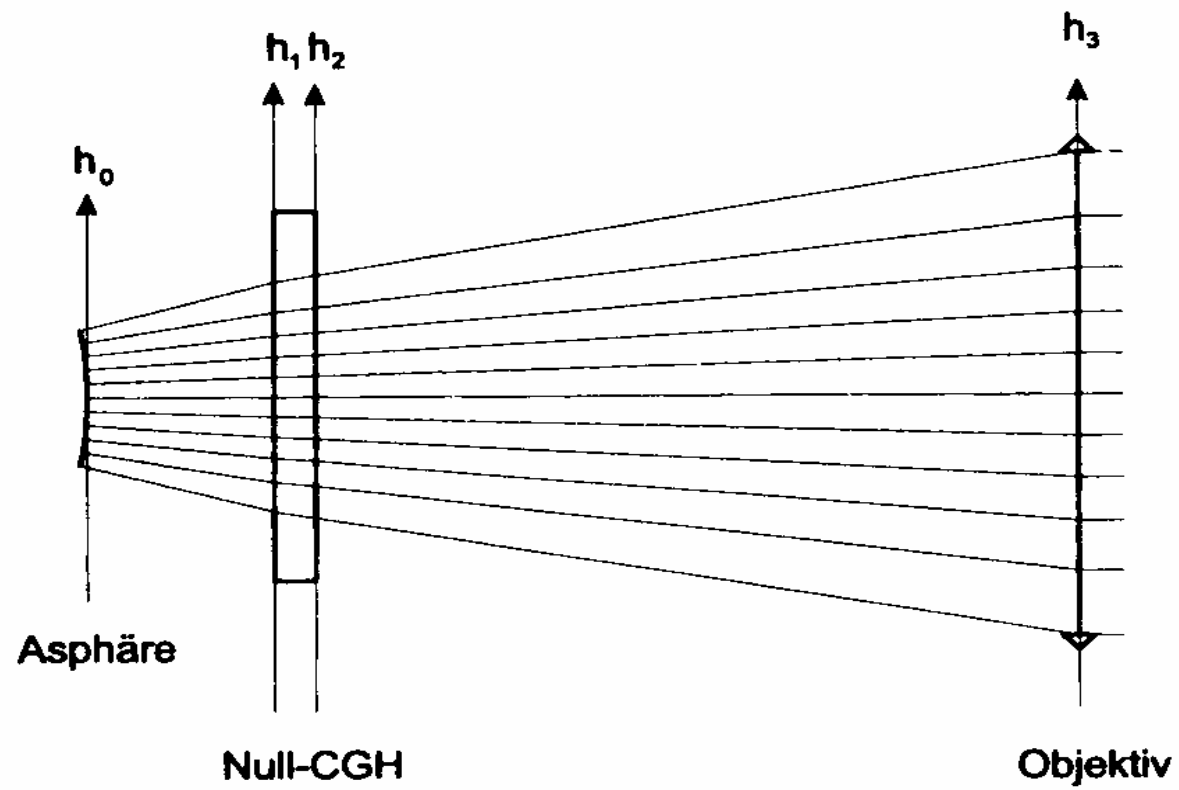


Künstliche
Vignettierung

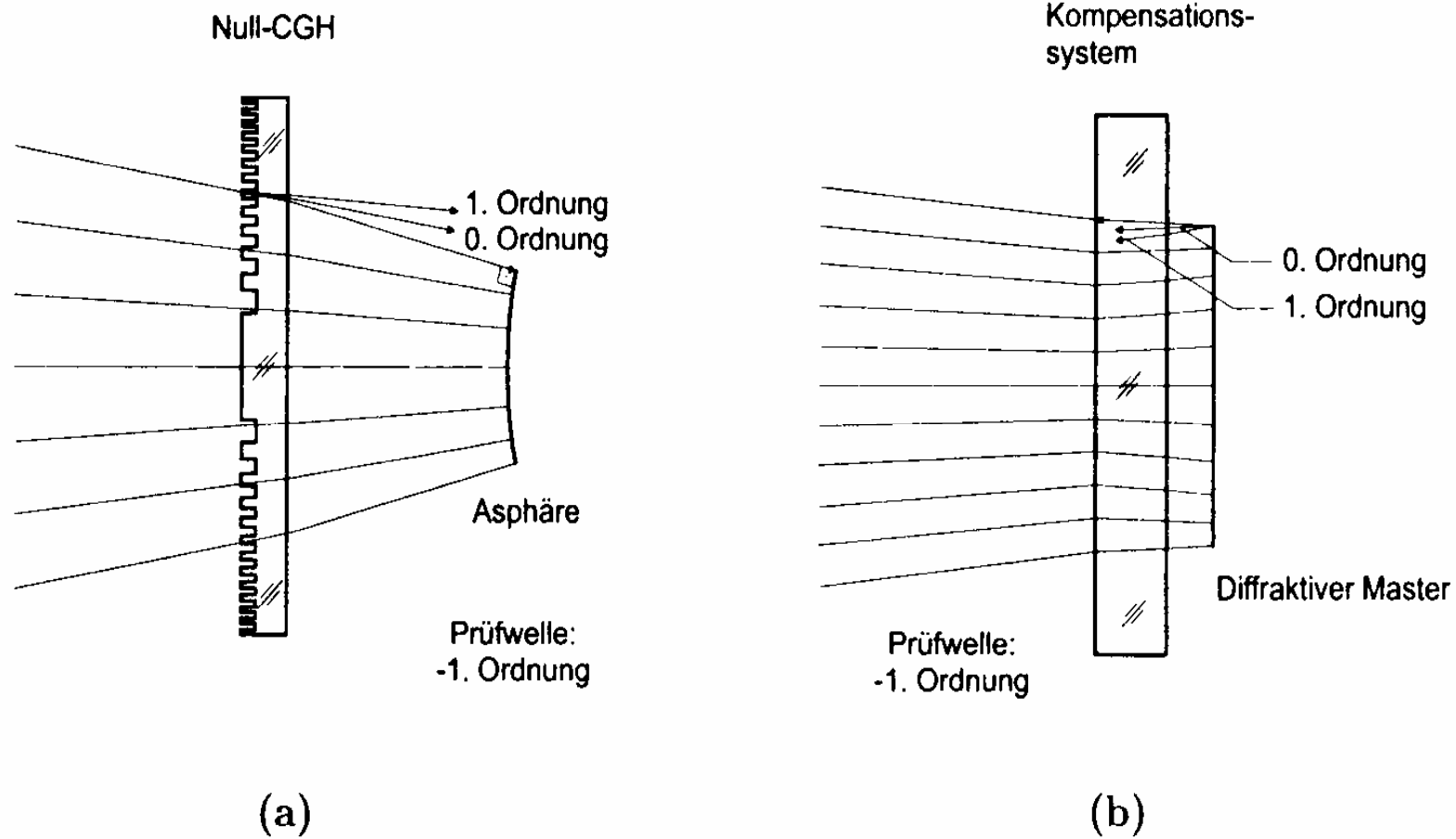
Unauswertbare
Streifendichte

Kompensierende Interferometer

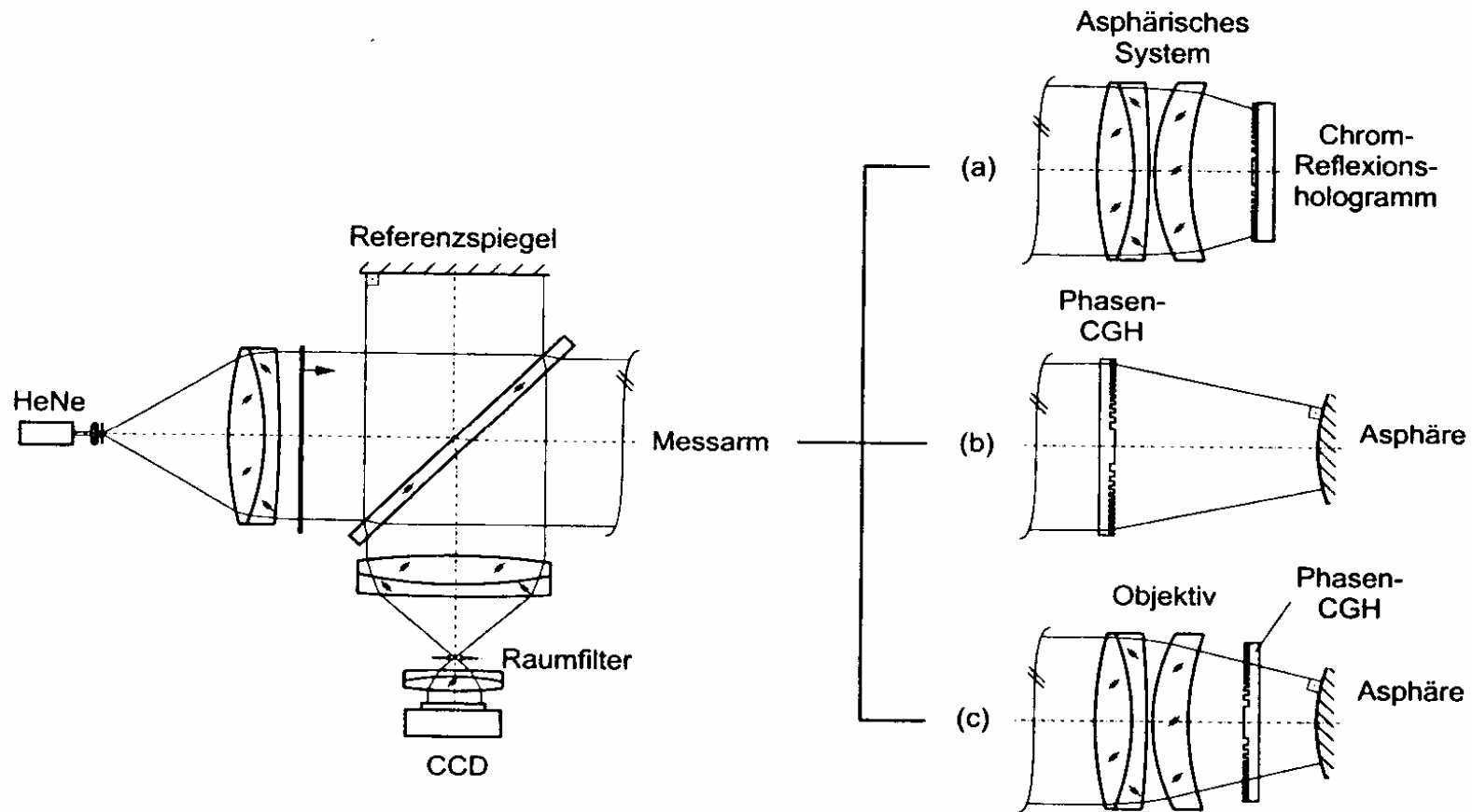


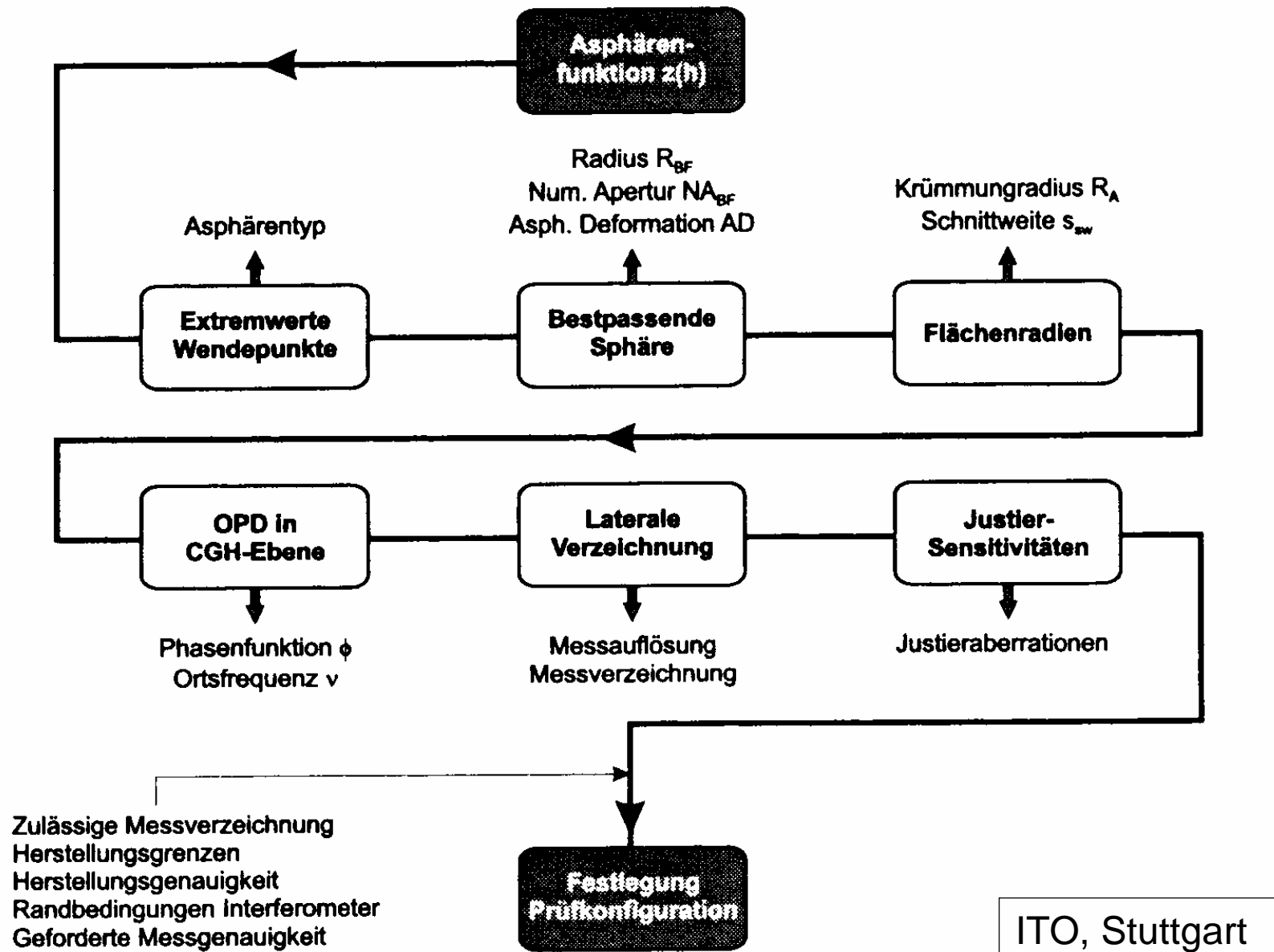


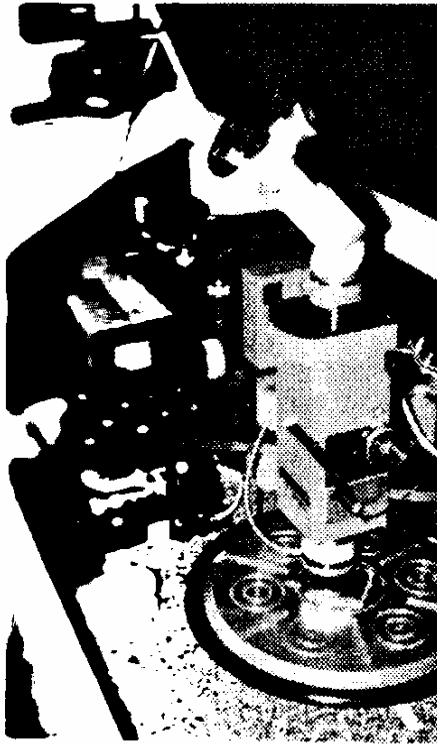
Kompensation von Ringen durch Hologramme



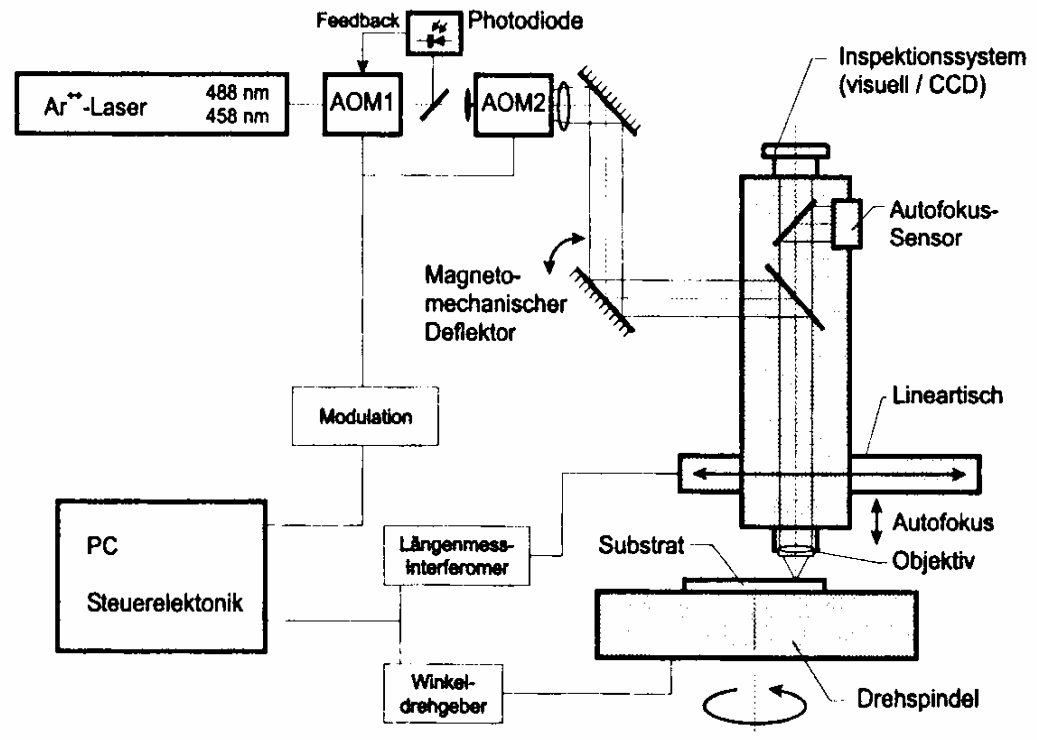
Interferometer-Anordnung mit Kompensationshologramm







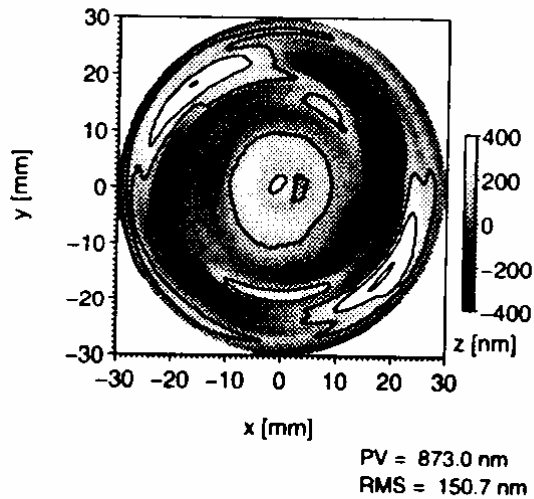
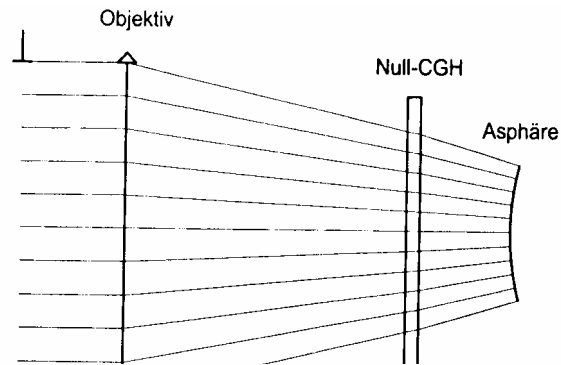
(a)



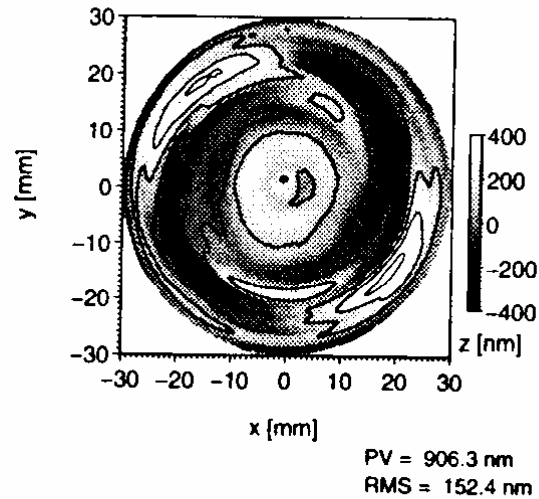
(b)

ITO, Stuttgart

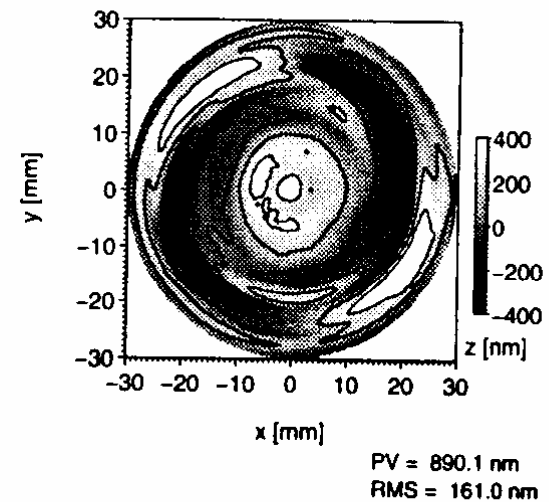
Kompensationshologramme (Null Hologramme)



(a) DI-CGH

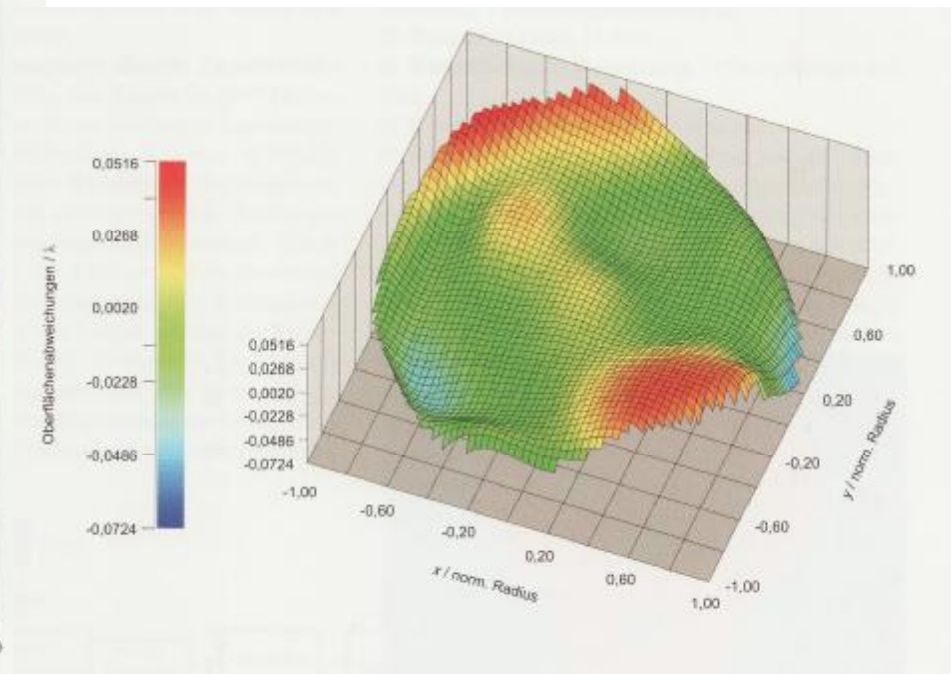
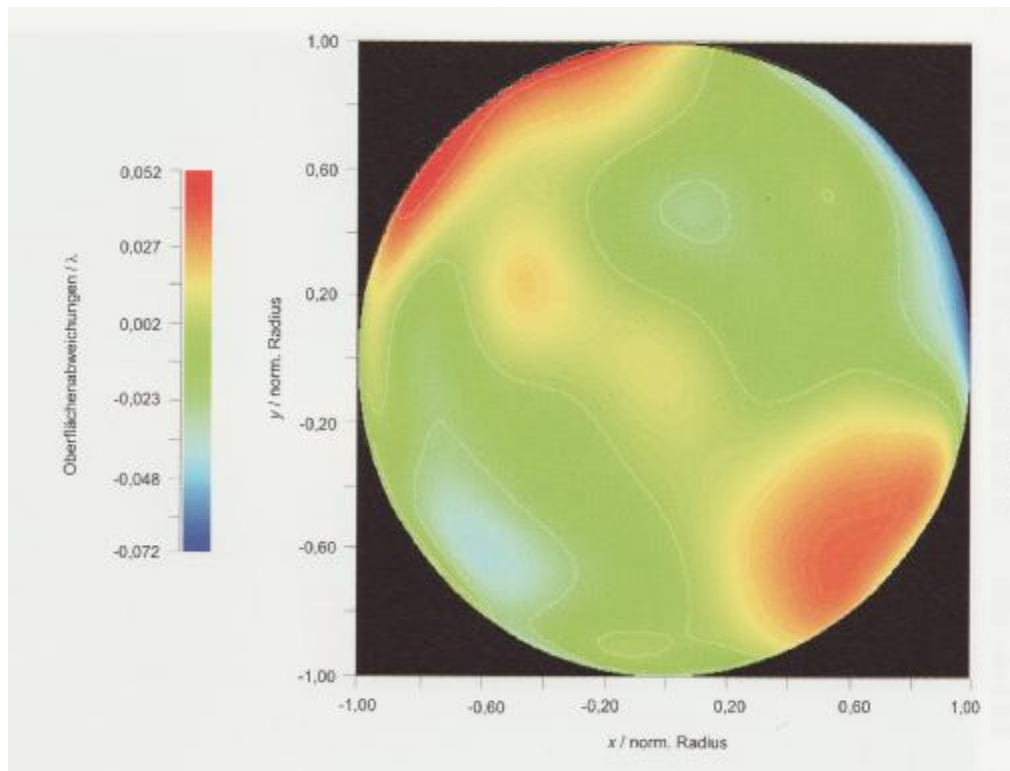


(b) ITO-CGH



(c) JO-CGH

Aufzeichnung der resultierenden Geometriefehler



Lexikon der
Optik

Kompensationshologramme

Vorteile:

Auflösung ca $10^{-3} \lambda$

Methode zur Prüfung von Gross-Serien

Übersichtliche Phasenauswertung mit vielen Messpunkten (Pixel der CCD Kamera)

Parallele, schnelle Messung

Nachteile:

Aufwendige Hologrammherstellung

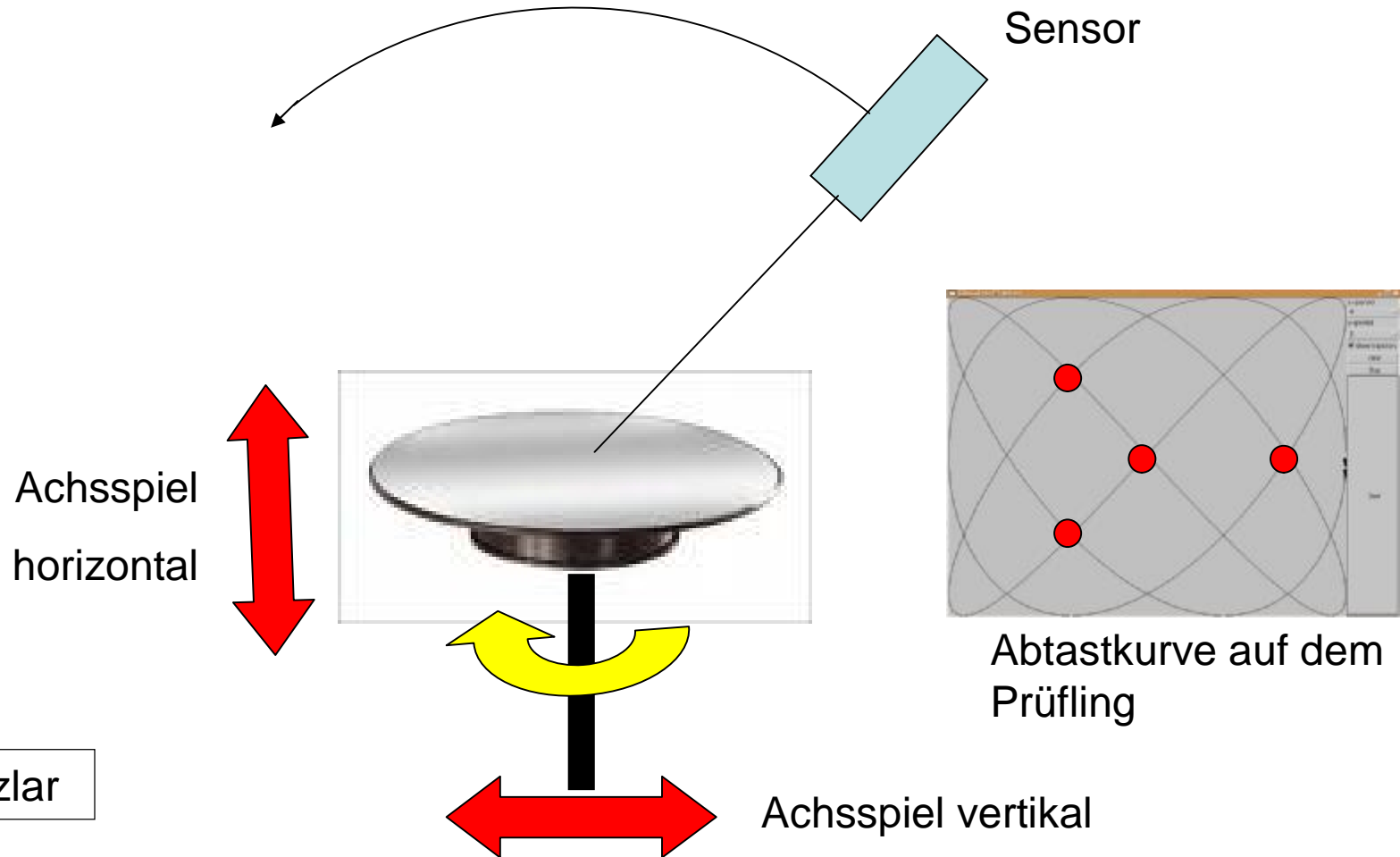
Grosser Justieraufwand

Unhandlich

Für Kleinserien nicht ökonomisch

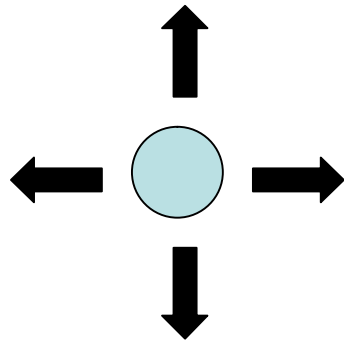
Abtastmethode (Oberflächenscanning)

Drehbewegung um horizontale Achse

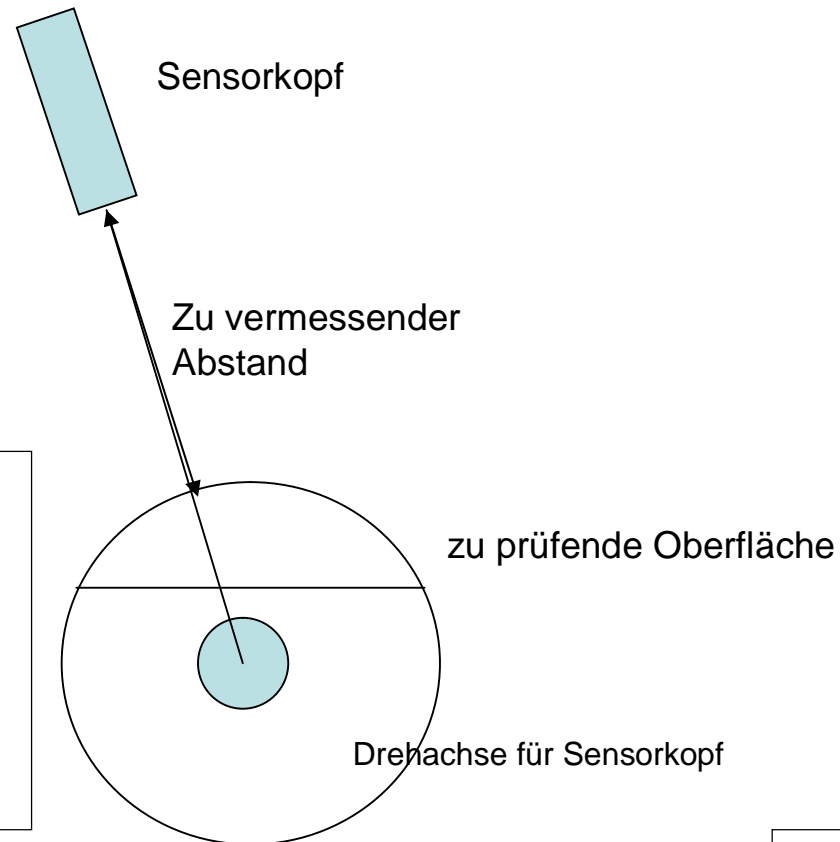


PZH Wetzlar

Abtastmethode (Oberflächenscanning)



Ungenauigkeit Achsenlage $\sim \pm 1 \mu\text{m}$
(60nm)
Einfluss horizontales Spiel ist weniger
gravierend
Einfluss vertikales Spiel gibt statistische
Ungenauigkeit von $\pm 1 \mu\text{m}$ (60 nm) in der
Abstandsmessung

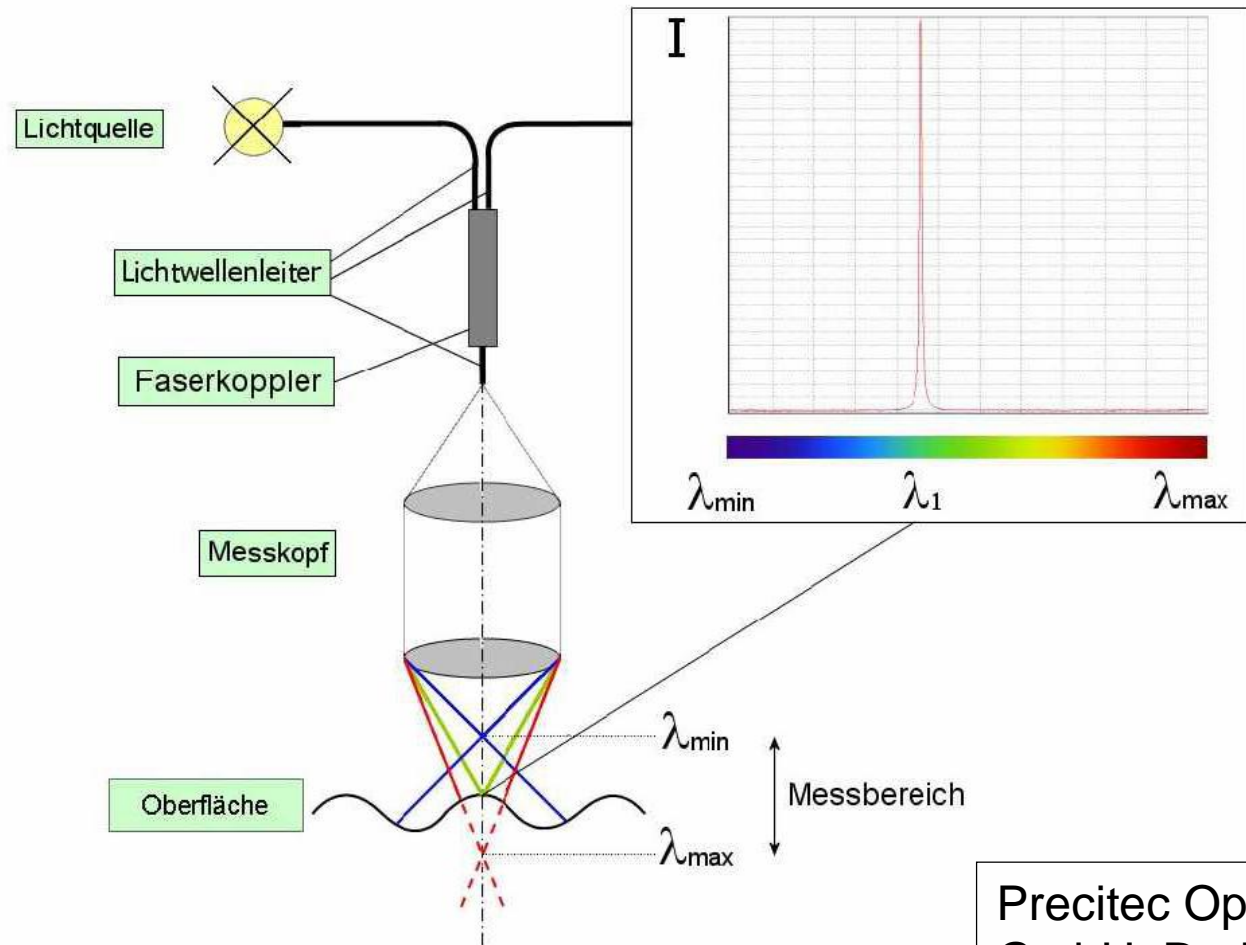


PZH Wetzlar

Meßköpfe

- Mechanische Tastköpfe
- Chromatische Meßköpfe
- Weisslichtinterferometer
- Mehrwellenlängeninterferometer
- Kombinationen davon

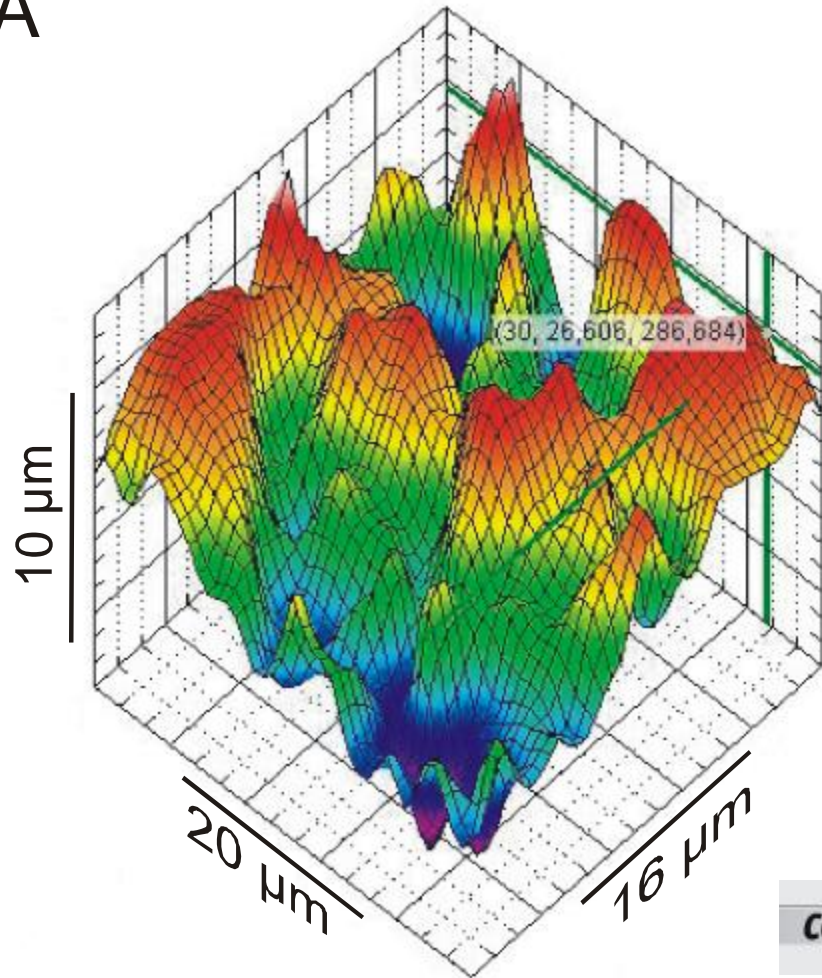
Chromatische Abstandsmessung



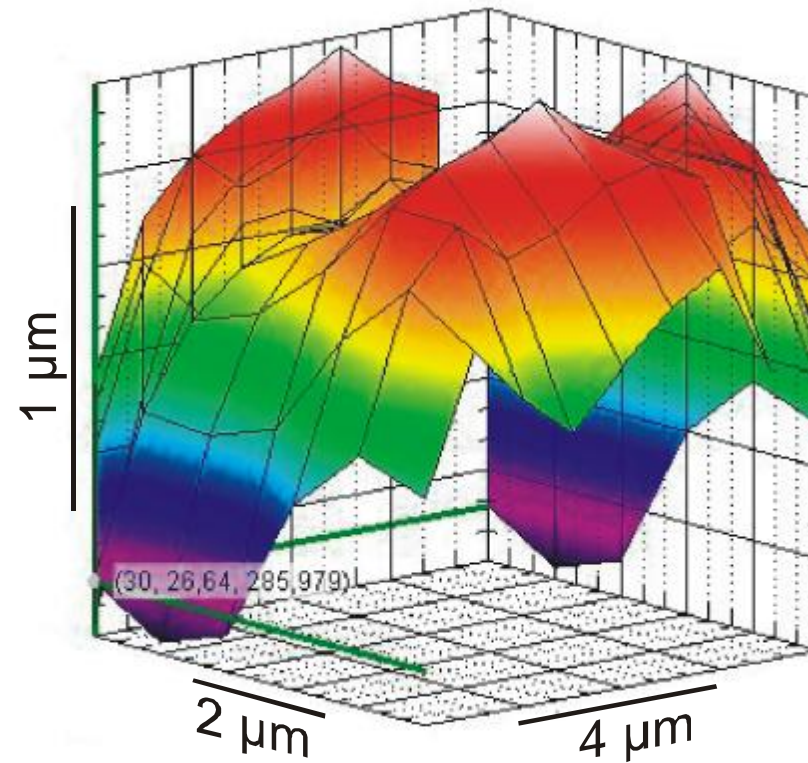
Precitec Optronic
GmbH, Rodgau

3D-Oberflächenmessung: Metall Stand der Technik

A



B



Messung: R. Heinecke, C3D



Abtastmethode

Vorteile:

Auflösung ca $10^{-3} \dots 10^{-4} \lambda$

Methode zur Prüfung von Klein- und Gross-Serien

Einfache Anpassung an neue Flächen

Übersichtliche Phasenauswertung
Stützwerte können einfach an die Problemstellung angepasst (reduziert) werden.

Auch für nicht polierte Flächen nutzbar

Nachteile:

Serielle Messung, Taktzeiten von Zahl der Stützwerte stark abhängig

Viele Messköpfe haben eingeschränkten Messbereich

Einschränkungen in der Genauigkeit durch Achslager

**Zur Lösung
Ihrer Probleme
helfen wir Ihnen
gerne.....**

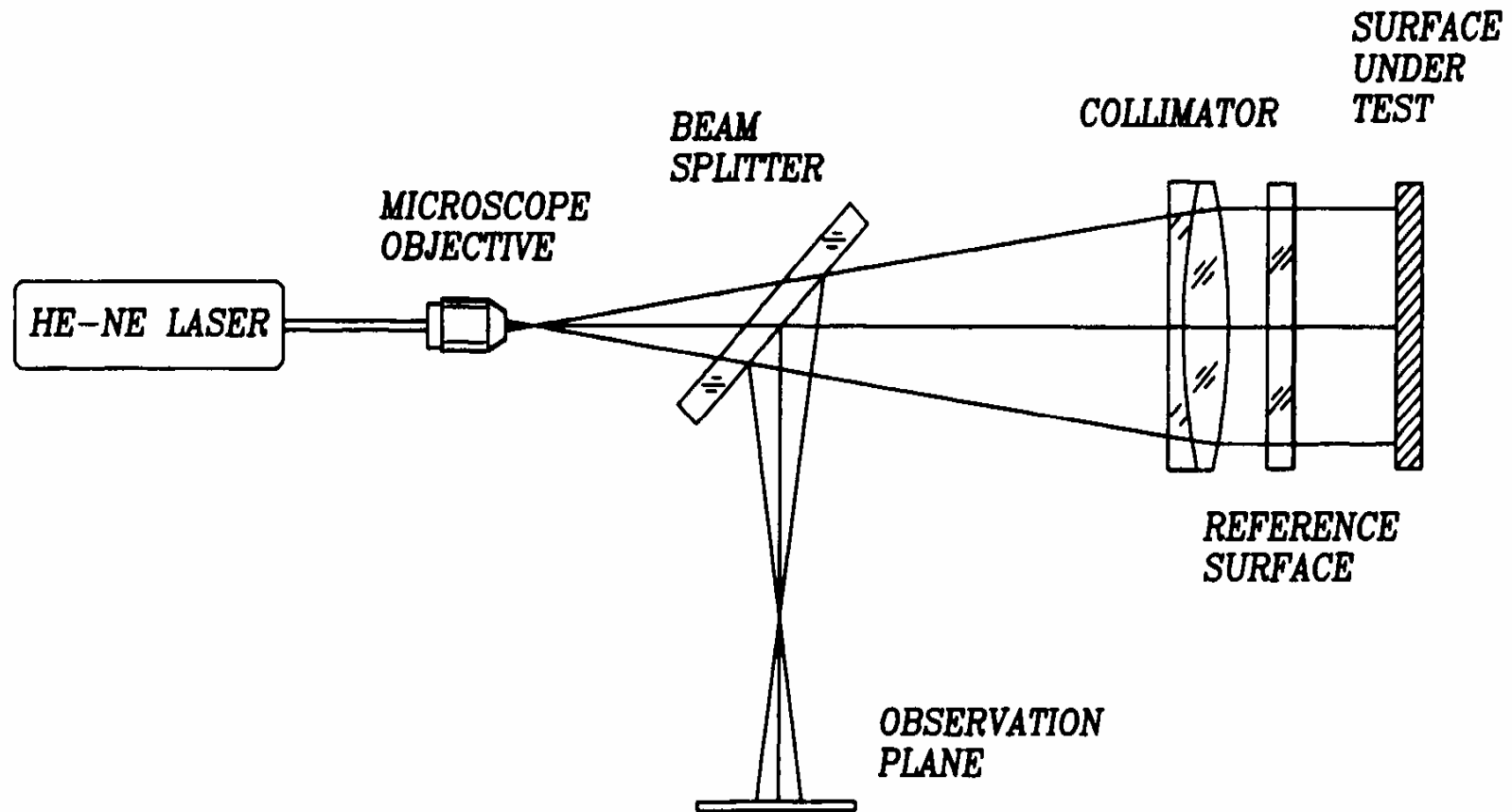
Vielen Dank!



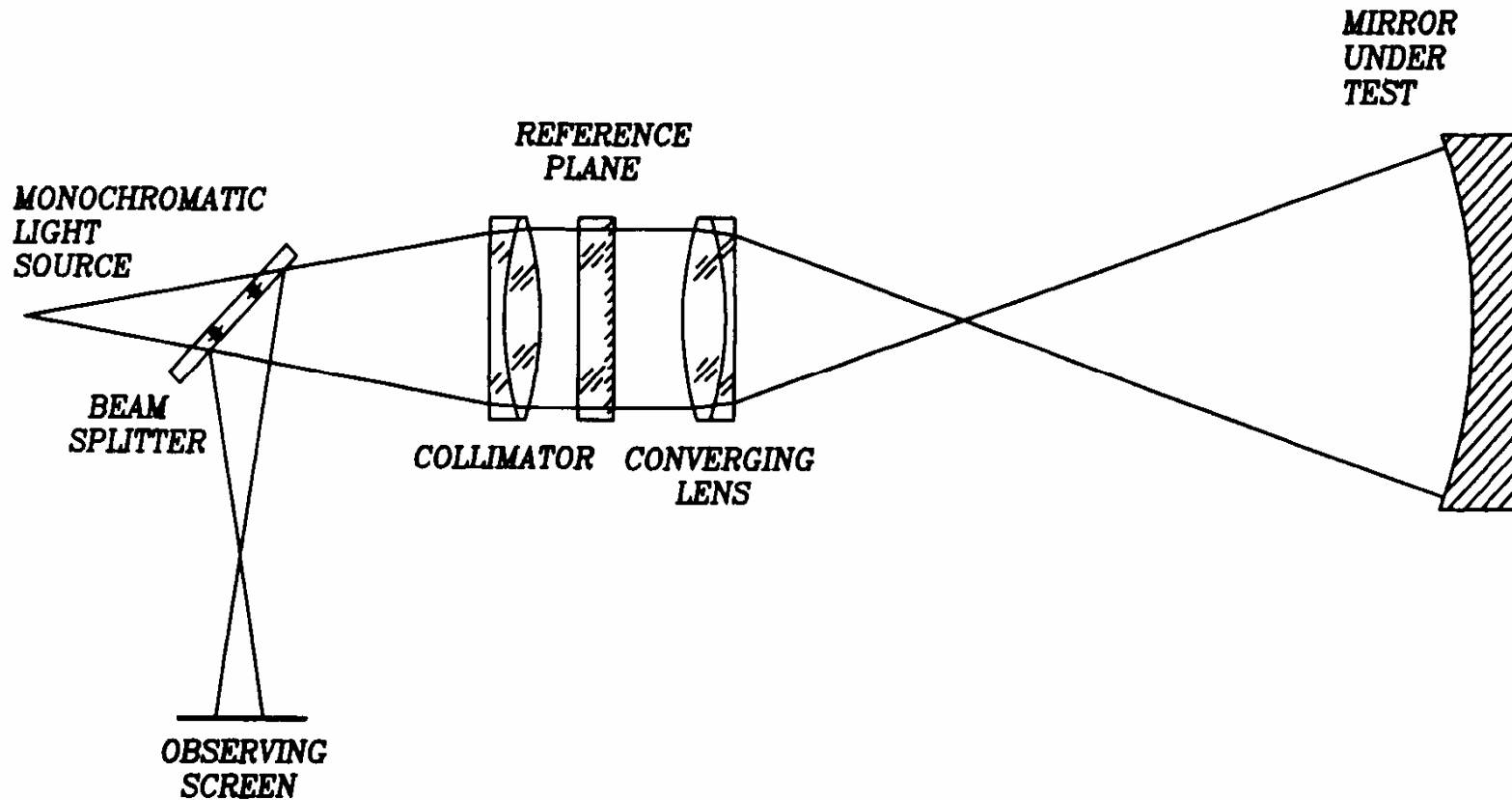
PZH

**Photonik Zentrum Hessen
in Wetzlar AG**

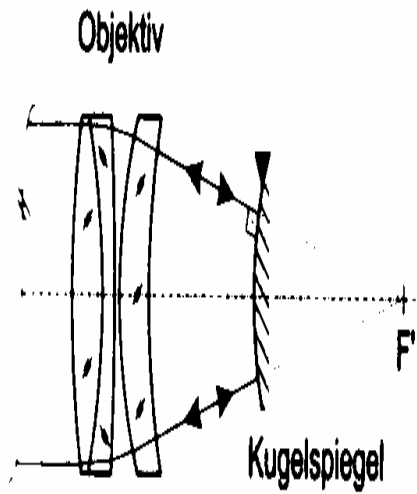
Fizeau Interferometer



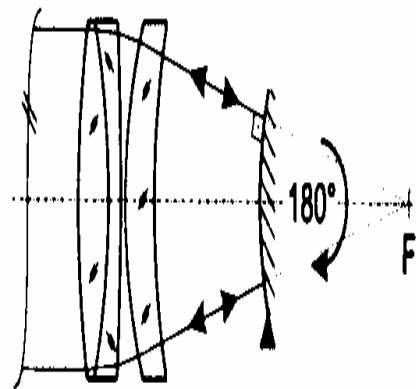
Fizeau Interferometer zur Kontrolle konkaver Oberflächen



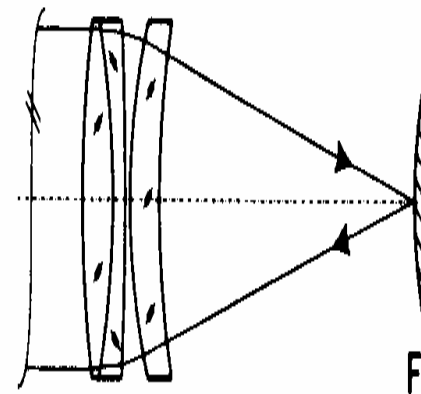
Grundposition (0°)



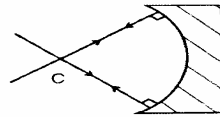
Gedrehte Position (180°)



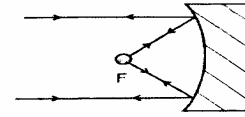
Katzenaugen-Position



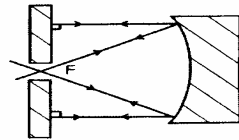
Viele Möglichkeiten



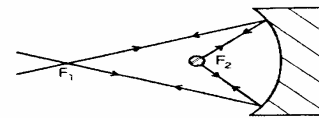
(a)



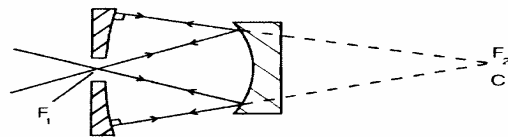
(b)



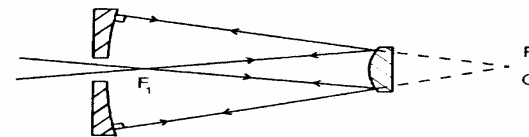
(c)



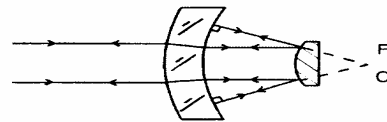
(d)



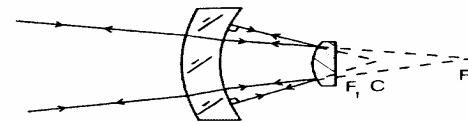
(e)



(f)

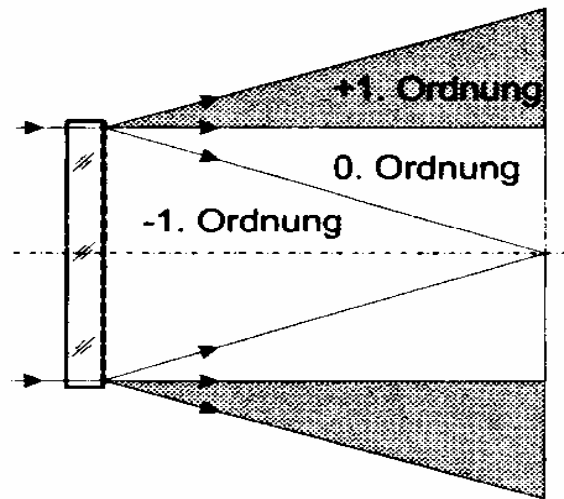


(g)



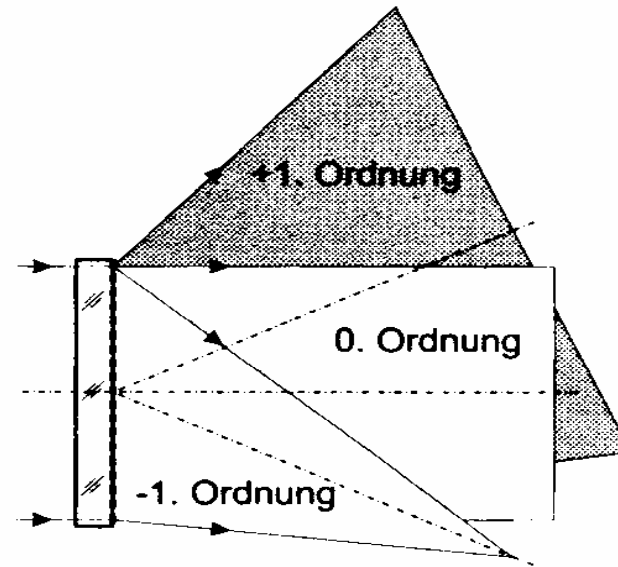
(h)

Inline-CGH



(a)

Off-axis CGH



(b)