Technology
Arts Sciences
TH Köln

Course
HO - Holography

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General information

Long name	Holography
Approving CModule	HO_BaET
Responsible	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Level	Bachelor
Semester in the year	summer semester
Duration	Semester
Hours in self-study	78
ECTS	5
Professors	Prof. Dr. Stefan Altmeyer Professor Fakultät IME
Requirements	mathematics: - vector calculus - complex numbers - Fourier transform physics / optics - paraxial optics - wave optics
Language	German
Separate final exam	Yes

Final exam

Details

As long as the number of participants is not too high, an oral examination is preferred over written exams.

Lowest competence level checked is knowledge. Questions could adress the definition of thick and thin gratings, the formulation of the grating equation for thick gratings for different angular situations, the numbers of achievable diffraction efficiency in amplitude- and phase holograms.

The next competence level is related to skills. Examination could be done by the task to find out the position of the different diffraction orders when a holographics setup is given, the diffraction efficieny of the different diffraction orders of a thin phase hologram are calculated, the requirements on temporal coherence in a holographic setup is used to find the maximum allowed linewidth of the laser in use, or to explain, what details have to be considered, when a holographic setup has to be built.

The highest competence level adressed is methodical expertise. It can be checked by a real world task: E.g. the design of a holographic setup to record digital holograms for a technical 3D contour measurement, the draft of an algorithm to calculate a digital hologram, the design of a procedure to copy holohrams, so that they can be reconstructed with white light instead of lasers. In a guided discussion or guided calculation it can be found out easily, if the underlying principles are understood and can be applied proactively, if intellectual transfer is made and if there is sufficient overview.

Minimum standard

Correct answer of at least 50 % of the questions

Exam Type

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Lecture

Learning goals

Knowledge

Characterisitcs of a hologram, difference to photos, stereograms, 3D cinema etc.

thin gratings
grating equation
exposure of gratings
influence of angles
influence of polarization
diffraction efficiency of thin gratings
amplitude gratings
phase gratings

Holographic imaging equations
recording of a hologram
reconstruction of a hologram
interpretation of the different diffraction orders
location of the diffraction orders
inline and side band holograms

zone plates
inline zone plates
interference of spherical and plane wave
focal points as real and virtual images
white light reconstruction, dispersion, orthoscopic and pseudoscopic image
interpretation as angular grating with variable perio
off axis zone plates
interference of spherical and plane wave
shift of spherical wave: shift of zone plate
tilt of plane wave: ellipitical deformation
increase in spatial frequencies
separation of real and virtual image
applications: measurement of particles, injection system design, respirable sprays

basic properties of holograms
transition from elementary holograms to complex holograms
dispersion in holograms
reconstruction with different wavelengths
reconstruction with white light
blurring in non image plane hologra,s
viewbox
in dependence on the image depth
recording with high aperture objectives
diffusors for aperture stretching in near image plane holography
image plane holography and dispersion
coherence requirements of reconstruction
light source extension and lateral image precision
spectral pureness and axial image precision

copying holograms
contact copy
copy with image plane shift
coherence requirements in copy processes

thick gratings
definiton
Bragg condition
efficiency

classificaion of holograms
interferogram of two point sources
locations of equal phase and euqality in distance difference
classification
thick and thin holograms
on- and off-axis holograms
transmission and reflxion holograms
Fourier holograms

white light holograms
Benton's white light holograms
thin white light hologram
reduction of perspective to one dimension
methods for recording and reconstruction
print copying
application: EC card, ID card, product labelling
Denisjuk holograms
thick white light hologram
Lippmann's color photography
principle of spectral filtering
depth of field, spectral properties, luminosity
rennisance due to new materials: photopolymer
RGB Denisjuks
applications: head-up display, sensor holograms, autostereoscopic displays

multiplexing of holograms
angular multiplexing
wavelength multiplexing
share of index modulation
applications: low content displays, RGB Denisjuk holograms

digital holograms
phase conserving interference of spherical waves
restriction to amplitude or phase due to recording materials
phase freedon of image points
Gerchberg Saxton algorithms, iterative Fourier transform algorithms
calculation of digital stereograms
phas shifting spatial light modulators: LCoS displays
applications: Diffractice Optical Elements, holographic ruler, flexible digital optics,
cinematic holography and displays

if there is enough time in the semester:

coupled wave theory of Kogelnik to calculate the diffraction efficiency of thick holograms.

Skills

Judge advantages and drawbacks of different technical 3D technologies

Calculate efficiencies of thin gratings

Calculate types and positions of different diffraction orders in off axis holograms

Apply the principles to spatially move and tune the efficieny of the different diffraction orders

Calculate the depth of field in holograms an find required parameters for the light sources

Classify holograms and choose the right application specific one

Choose the right copy process for each application

Design holographic setups application specific

Calculate digital holograms

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Lecture	2
Tutorial (voluntary)	0

Separate exam

none

Practical training

Learning goals

Skills

align laser to optical axis

setup spherical and plane waves

plan foldes beam paths

align complex optical setups

balance optical paths in asymmetric setups

make and use a setup for Denisjuk holograms

make and use a setup for zone plates

make and use a setup for gratings

make and use a setup for off axis holograms

make and use a setup for rainbow copies

make and use a setup for digital holography with an LCoS display

Expenditure classroom teaching

Type	Attendance (h/Wk.)
Practical training	2
Tutorial (voluntary)	0

Separate exam

Exam Type

working on projects assignment with your team e.g. in a lab)

Details

1) Written examination questions and complex calculations, which require to find a suitable Ansatz, related to the experiment have to be prepared at home.

2) The homework is discussed with all participants at the beginning of the laboratory. The underlying ideas of the experiments have to be explained at the beginning of the laboratory and are discussed extensively.

3) Make the experiment alone in a team of two.
- Build up and adjust your own setup
- record and reconstruct holograms with this setup

Minimum standard

All written tasks must have been delt with.

The basic ideas of the experiment must have been understood.

All experiments must have been performed.