

Einführung in die Farbwissenschaft

Physics of Color

Light – Basic Properties

- visible light is electromagnetic radiation in a particular region of the entire spectrum
- distinguishing criterion: its frequency

$\sim 380 - 780 \text{ nm} \approx 780 - 380 \text{ GHz}$

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Light – Spectrum

- normally, a ray of light contains many different waves with individual frequencies
- the associated distribution of wavelength intensities per wavelength is referred to as the *spectrum* of a given ray or light source

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Light – Particles or Waves?

- light waves usually propagate according to the laws of geometric optics (as photons)
- however, certain properties can only be described by taking their wave nature into account

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Light – Particles or Waves?

- a *photon* (Greek φωτός, photos = light) is the elementary particle responsible for electromagnetic phenomena, the carrier of electromagnetic radiation
- as all elementary particles: photons have wave *and* particle properties („*wave-particle-duality*“)

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Wave Types

- longitudinal wave* = compression wave
 - vibrations *parallel* to direction of travel
 - example: sound
- transverse wave* = swinging wave
 - vibrations *perpendicular* to direction of travel
 - example: water, *light*

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Light – Coherence



- light is a transverse wave
- its frequency alone is sometimes not sufficient to describe a given wave train
- temporal coherence
- spatial coherence
- spectral coherence
- polarization coherence

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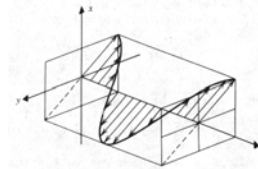
6



Light – Polarization



- for polarization coherent beams of light, oscillation direction has to be maintained
- the oscillation distribution is referred to as the polarization state of a light ray

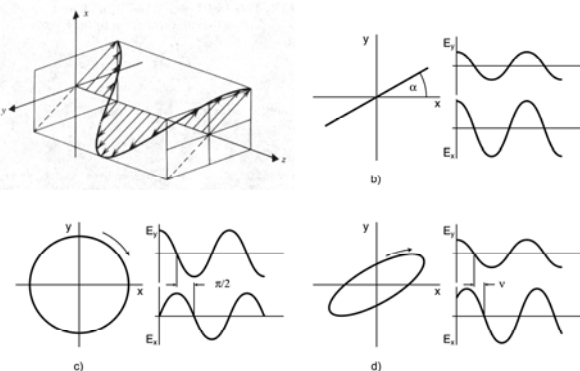


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7



Linear and Circular Polarization



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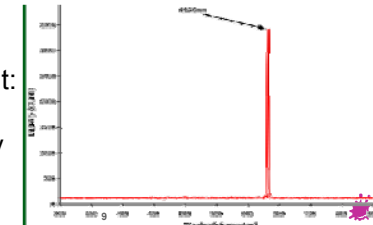
8



Laser-Light



- **L**ight **A**mplification by **S**timulation of **E**mitted **R**adiation
- produces temporal and spatial coherent light
- laser light is initially unpolarized, but all photons are in phase and usually of the same frequency
- main difference to „ordinary“ light: propagates in almost perfectly straight line



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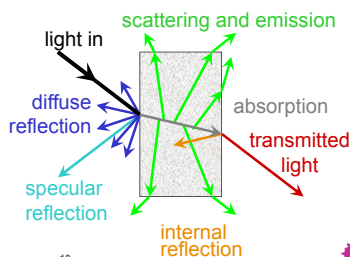
9



Causes for Light Color



- for directly viewed emitters, only their characteristics have to be considered
- in all other cases, the interaction of light with the objects in a scene is at least partially responsible for the perceived color of an object



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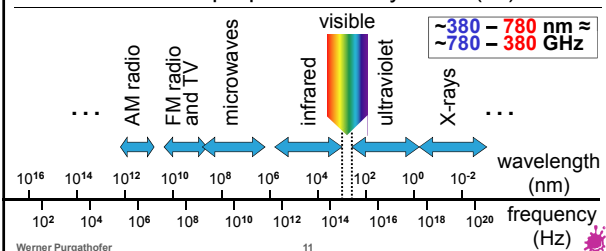
10



Energy Levels & Visible Range



- a light frequency corresponds to a wavelength and has an energy level $E = \text{const}/\lambda$
- „seeing“: in the visible range of humans:
 - ◆ higher → energy destroys molecules (UV)
 - ◆ lower → no proper focus any more (IR)



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11



- quantum systems such as molecules can only exist in certain discrete states

- only certain transitions between these states are allowed

- the states correspond to energy levels

