Aspects of Photography and Optical Microscopy

Resolution – Aperture – Depth of Field
Exposure Time — S/N
White Balance

Prof. Dr. Benjamin Butz

UNIVERSITÄT SIEGEN

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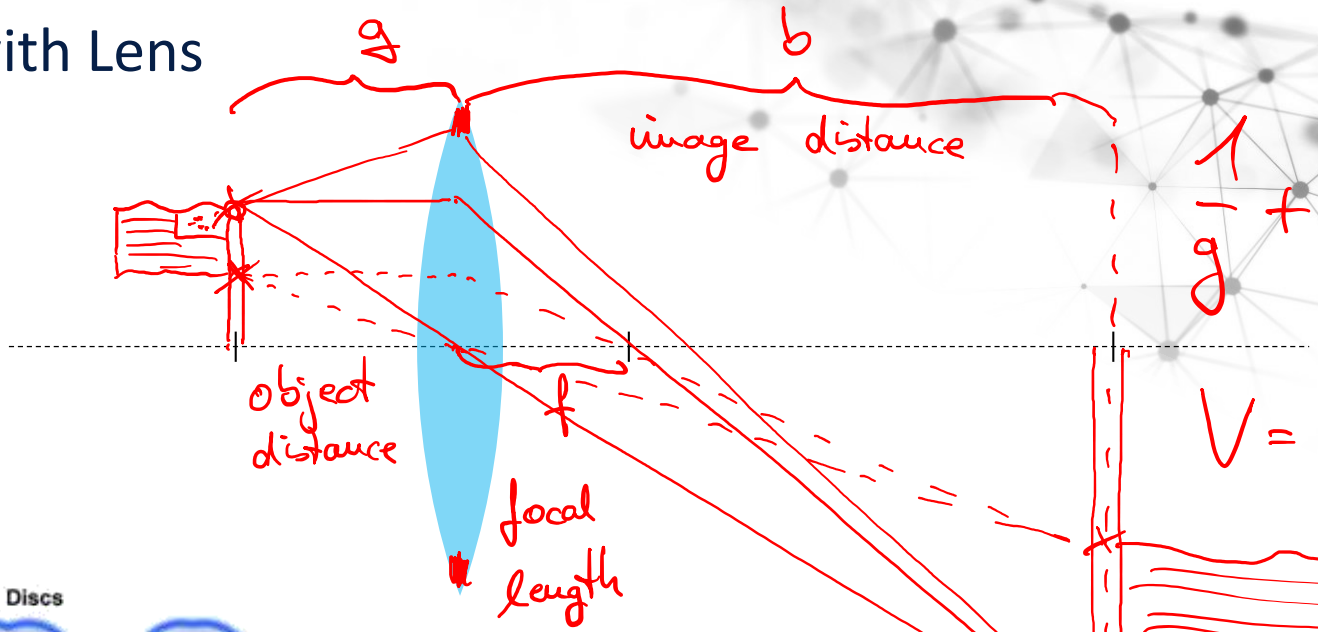
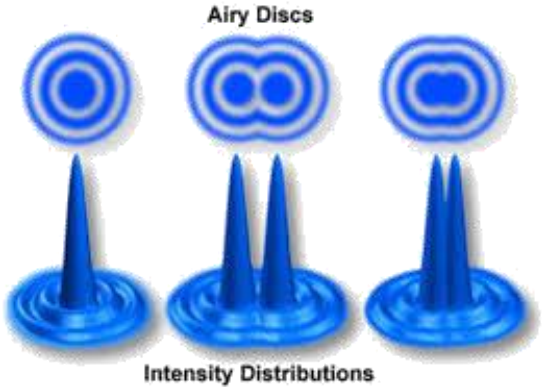
Imaging with Lens



$$\frac{1}{g} + \frac{1}{b} = \frac{1}{f}$$

$$V = \frac{b}{g}$$



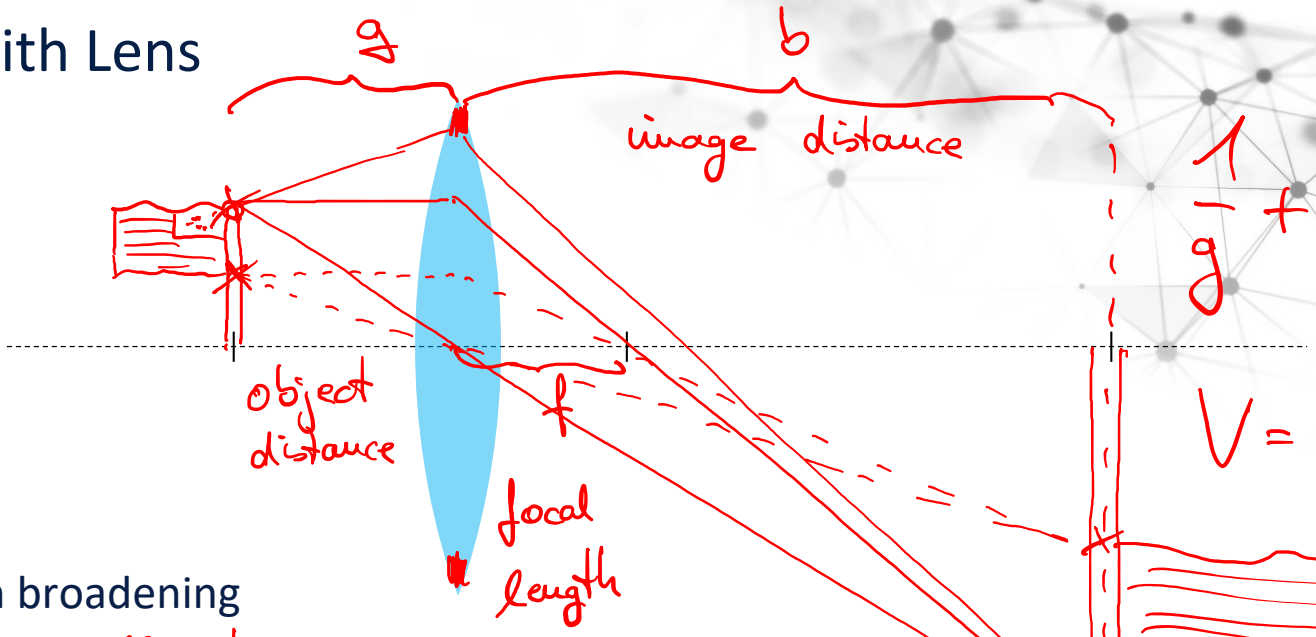
Finite aperture opening

⇓

Airy discs for each image of an infinitesimal object point ⇒ If seperable then resolved !

www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/numaperture/

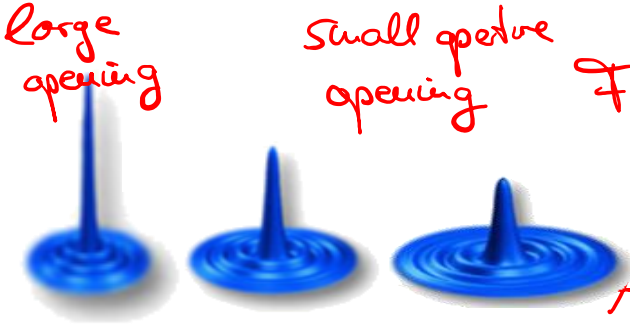
Imaging with Lens



$$\frac{1}{g} + \frac{1}{b} = \frac{1}{f}$$

$$V = \frac{b}{g}$$

Diffraction broadening



Airy discs for each image of an infinitesimal object point ⇒ If seperable then resolved !

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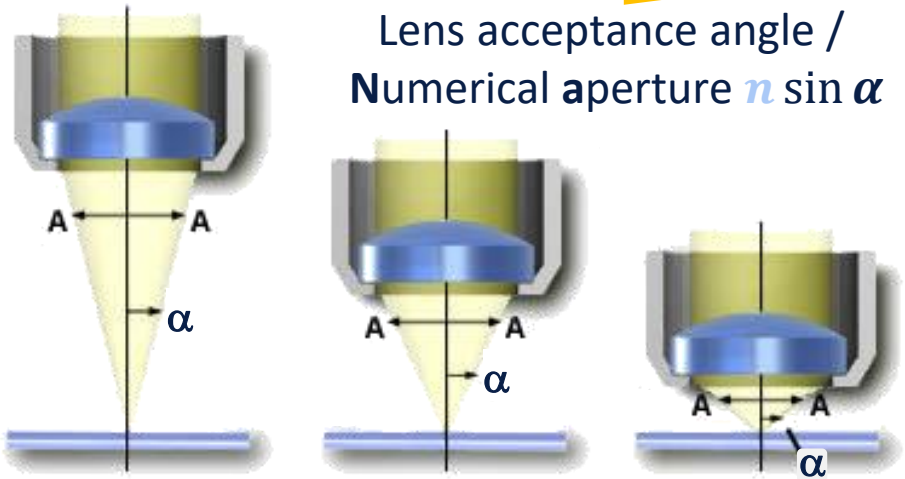
Resolution of Optical Microscope

Lens acceptance angle /
Numerical aperture $n \sin \alpha$



α = 7°
NA = 0.12
~3µm

α = 20°
NA = 0.34

α = 60°
NA = 0.87
~400nm

$$d = \frac{\lambda}{2n \sin \alpha}$$

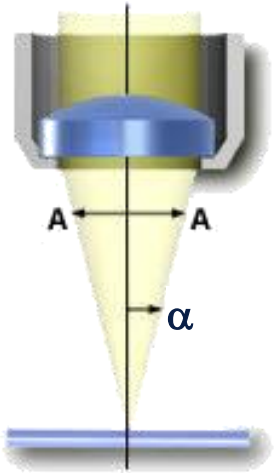
d minimum resolvable distance
λ wafelength of light
n refrective index; here 1 (air)
α half opening angle of light cone

Mag	NA	Res / µm
4x	0.10	2.75
10x	0.25	1.1
20x	0.40	0.69
40x	0.65	0.42
60x	0.75	0.37
100x	0.95	0.3

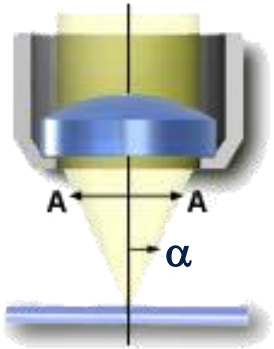
www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/numaperture/

Resolution of Optical Microscope

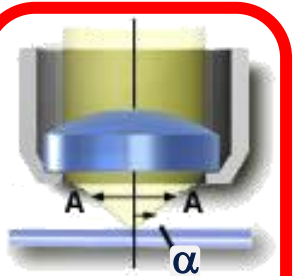
Lens acceptance angle /
Numerical **a**perture $n \sin \alpha$



α = 7°
NA = 0.12

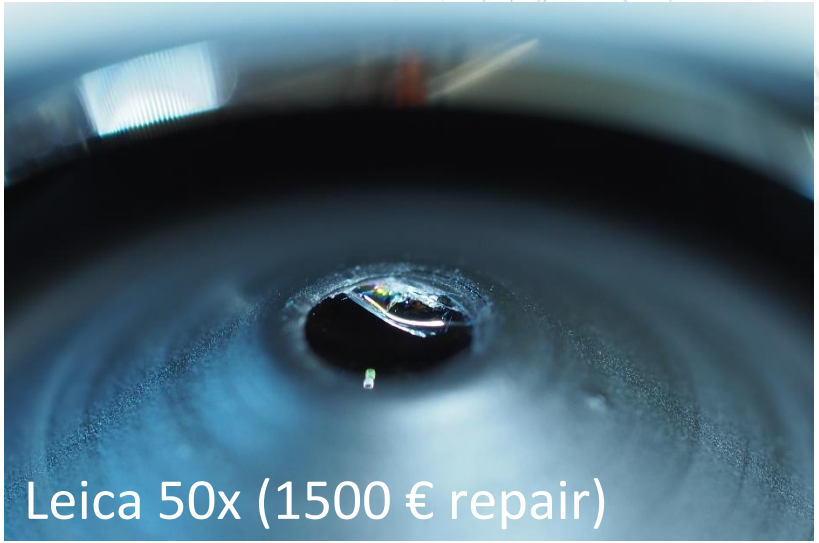


α = 20°
NA = 0.34



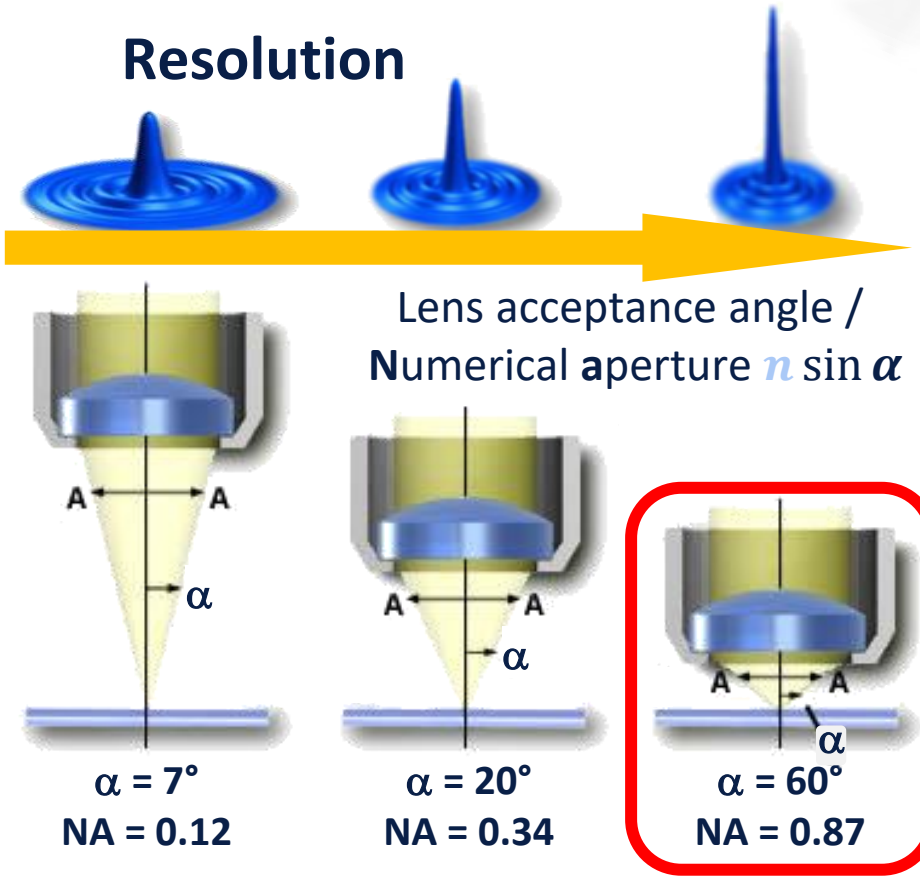
α = 60°
NA = 0.87

Working distance only few 100 µm!

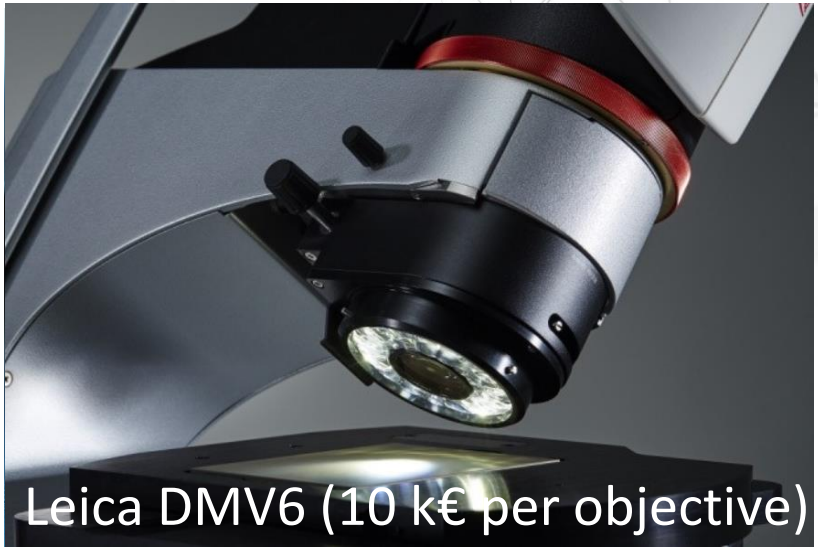


www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/numaperture/

Resolution of Optical Microscope

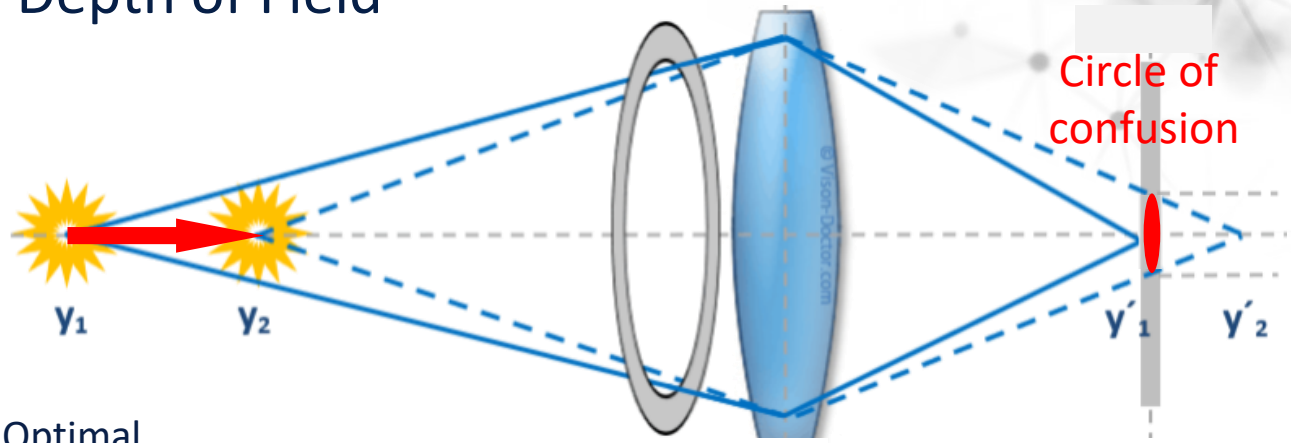


Large working distance by larger lenses



www.olympus-lifescience.com/en/microscope-resource/primer/anatomy/numaperture/

Depth of Field



Large aperture

"Offenblende"

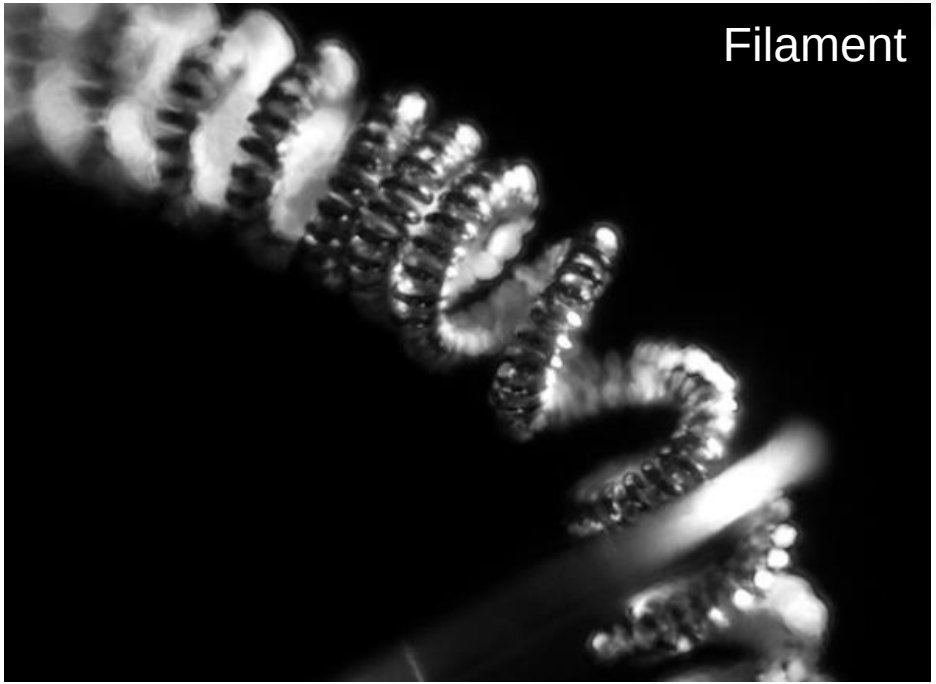
→ Limited depth of field

High resolution

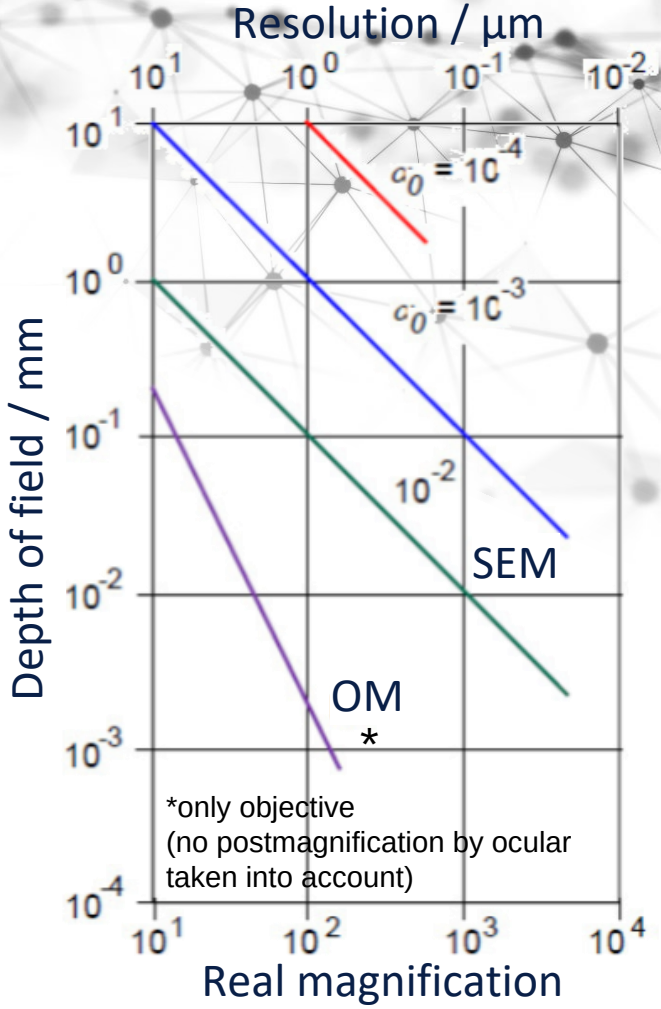
High intensity/ short exposure

www.vision-doctor.com/optische-grundlagen/schaerfentiefe.html

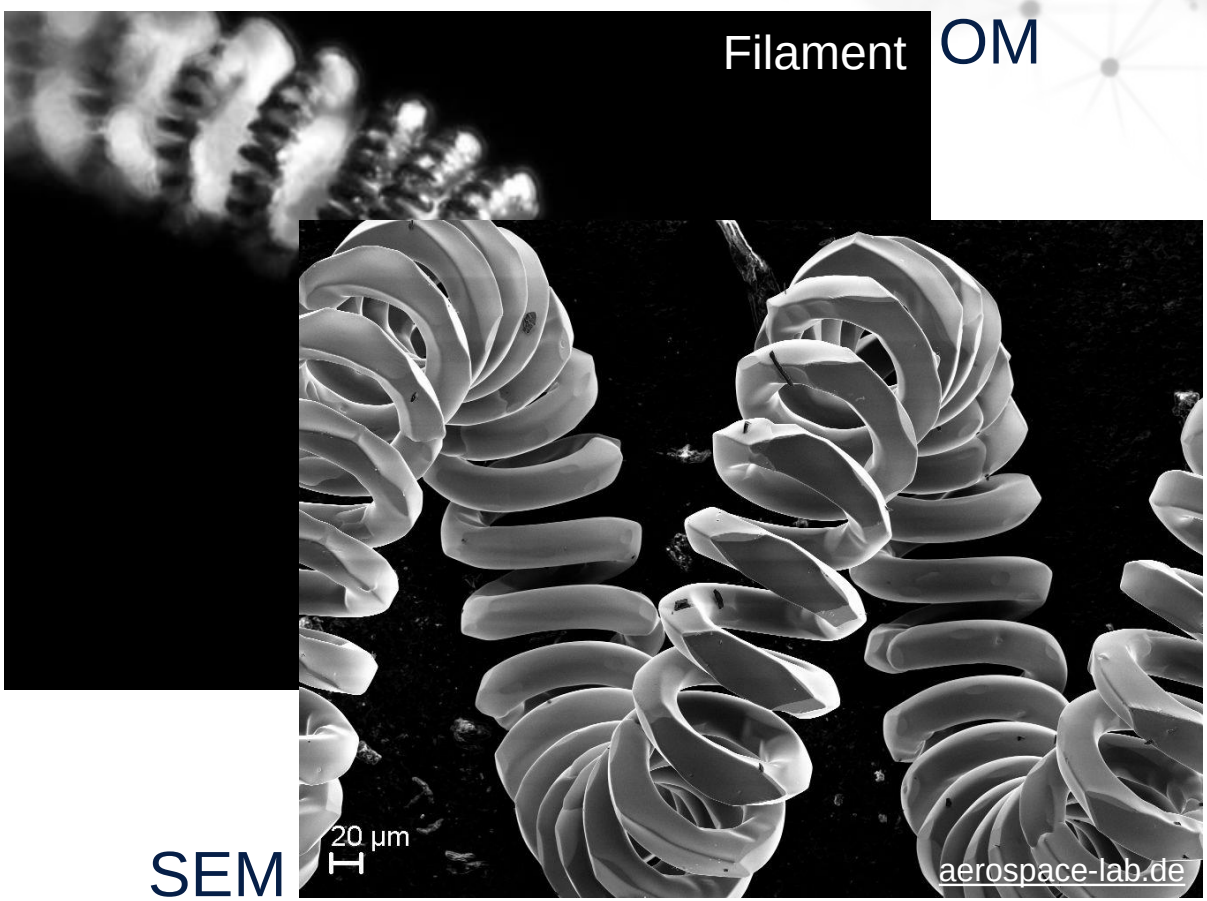
Limited Depth of Field in OM → SEM!

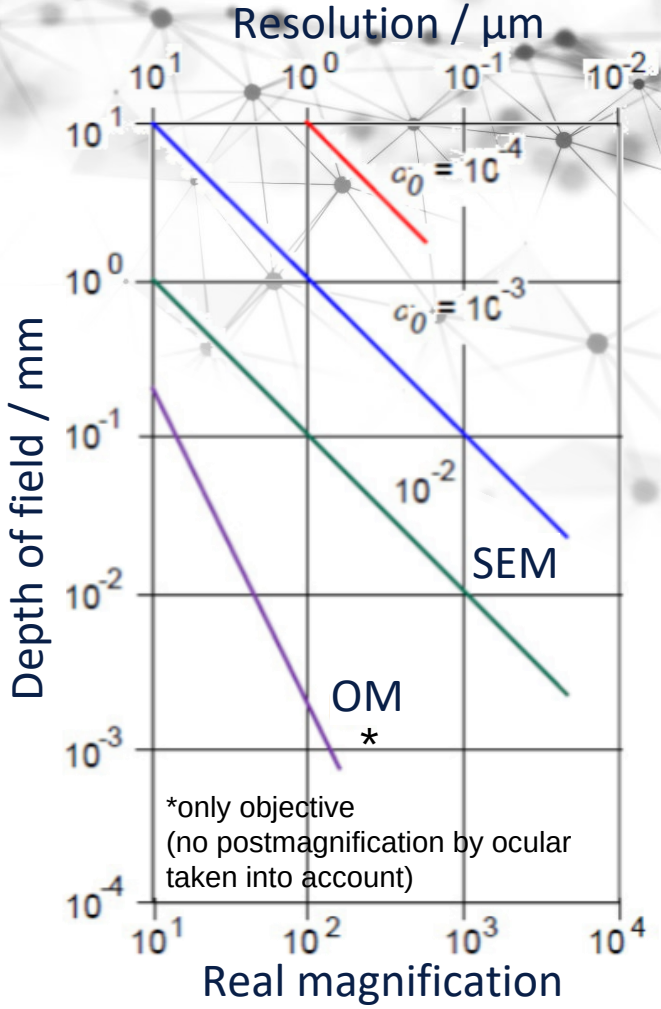


OM

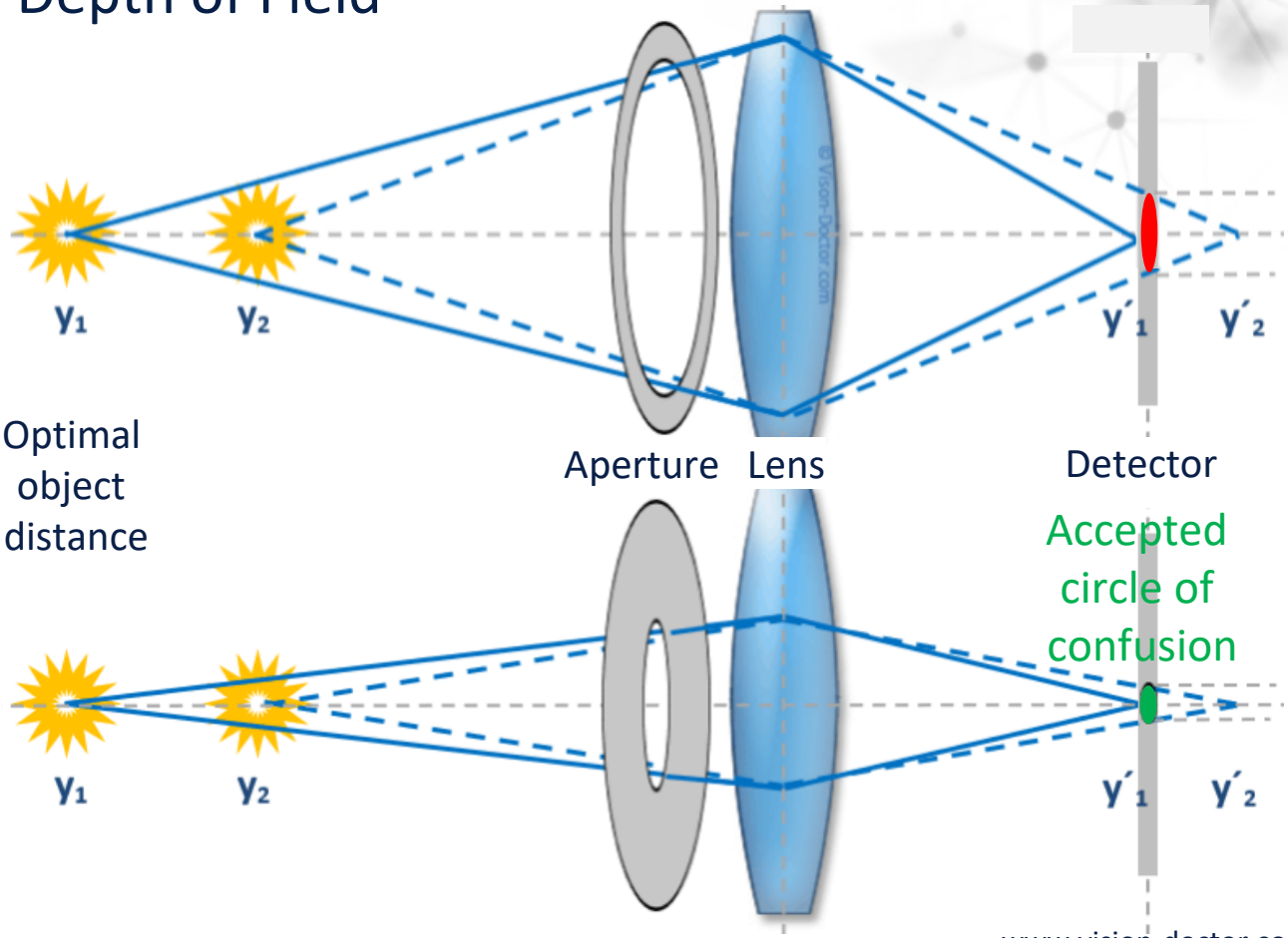


Limited Depth of Field in OM → SEM!





Depth of Field



Large aperture

"Offenblende"

→ Limited depth of field

High resolution

High intensity/ short exposure

Small aperture

"abgeblendet"

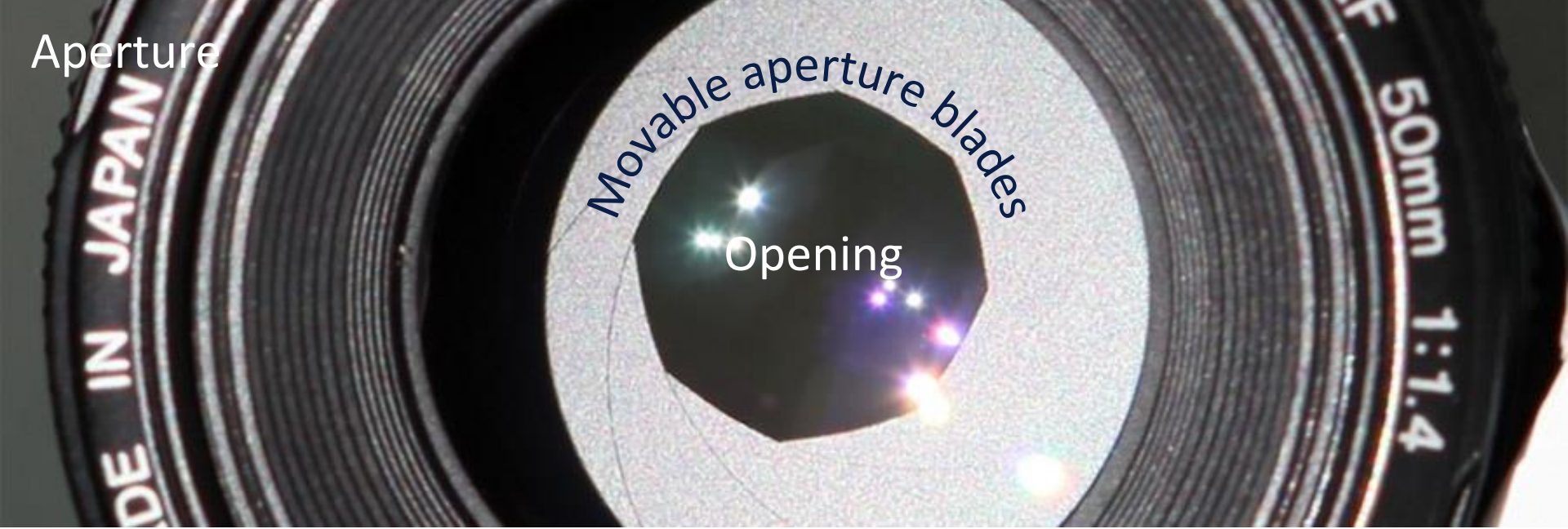
→ Large depth of field

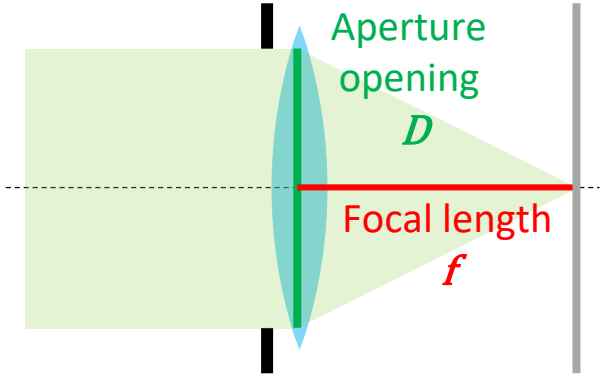
Limited resolution

Low intensity/ long expose

www.vision-doctor.com/optische-grundlagen/schaerfentiefe.html

Aperture

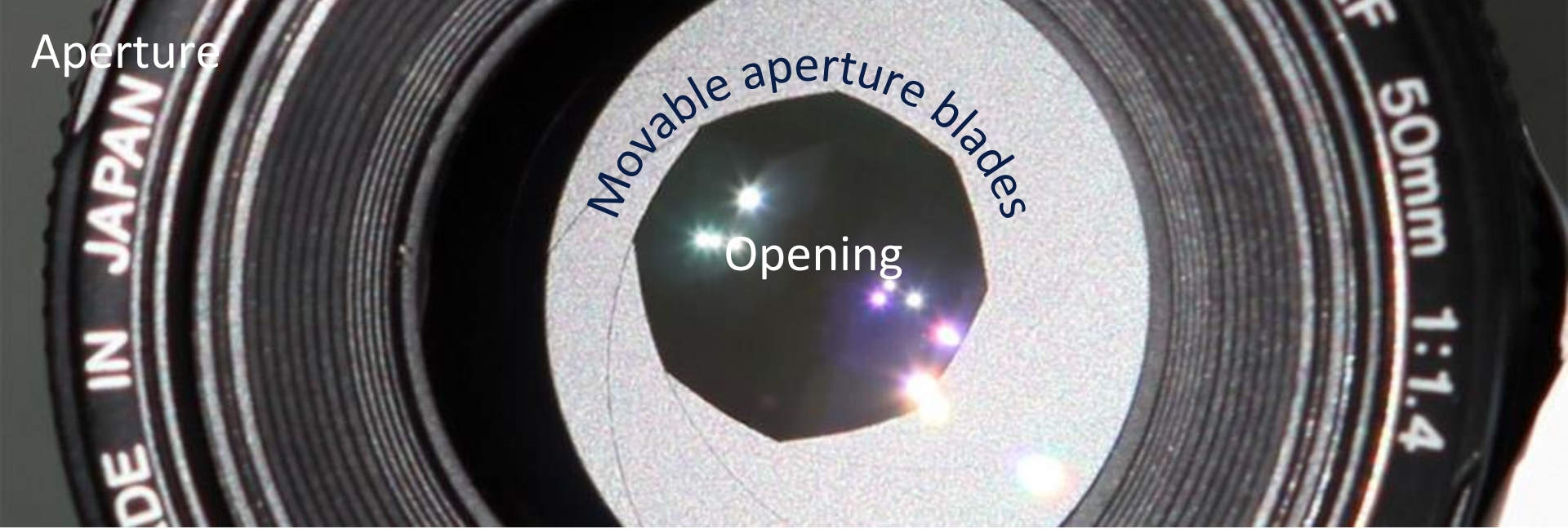


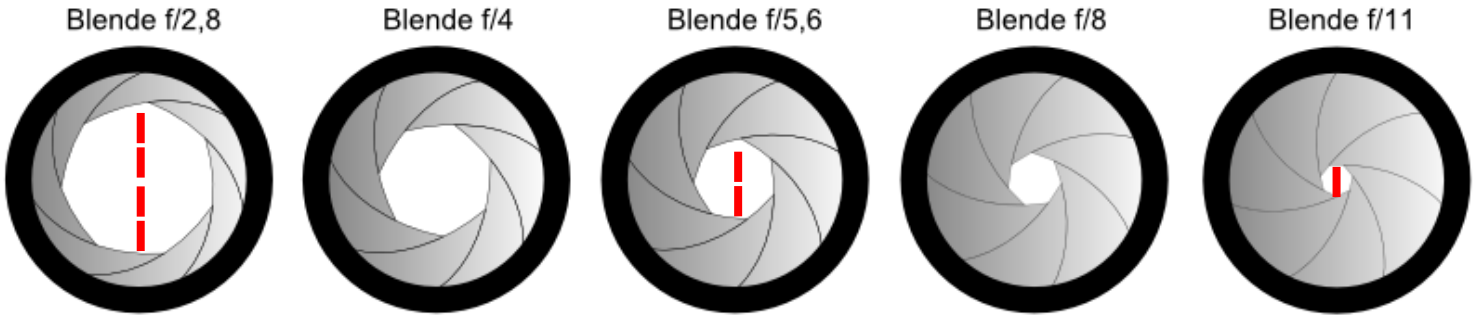


$$\text{Aperture number } N = \frac{f}{D}$$

www.foto-kurs.com/bilder/blenden-28-bis-11.png

Aperture





www.foto-kurs.com/bilder/blenden-28-bis-11.png

Aperture — Exposure Time

Aperture opening diameter:

$$D = f : N$$

Aperture opening area:

$$A = \pi\left(\frac{D}{2}\right)^2 = \pi\left(\frac{f}{2N}\right)^2$$

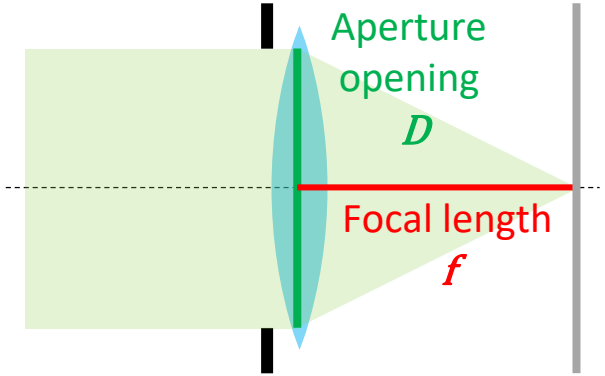


Image intensity:

$$I = j \cdot A \cdot t$$

I: Photon current; t: Exposure time

$$\Rightarrow t = \frac{I}{j \cdot A} \propto N^2$$

N: $1;\ 1.4;\ 2;\ 2.8;\ 4;\ 5.6;\ 8 \ldots$

t: $t_0;\ \frac{t_0}{2};\ \frac{t_0}{4};\ \frac{t_0}{8};\ \frac{t_0}{16};\ \frac{t_0}{32};\ \frac{t_0}{64};\ \ldots$

Aperture — Exposure Time

f/ 2,8

Blende variabel:
100mm | 0,5 Sek. | ISO **100**

Aperture number ↑
Opening area ↓

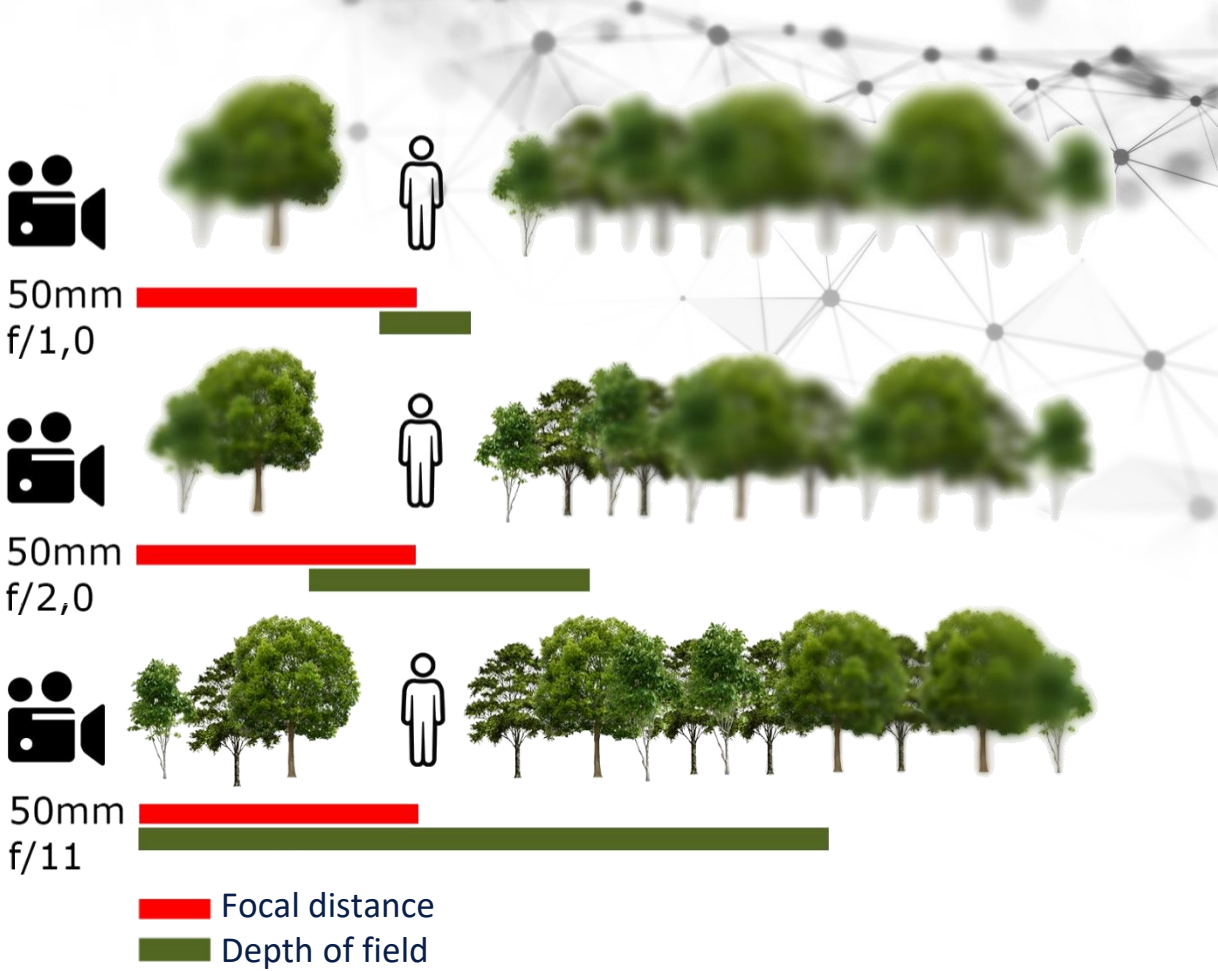
Exposure time ↑
(!drift/smearing!)
OR
Sensitivity (ISO) ↑
(!noise!)

Markus Mayer/ApolloWissen (https://de.wikipedia.org/wiki/Sch%C3%A4rfentiefe)

Depth of Field

DOF depends on

- Aperture
- Focal distance
- Focal length



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Depth of Field – Calculation

Schärfentiefe-, Abbildungsmaßstab- und Nahlinsenrechner

Version 0.8.19 vom 1.4.2019, Special Edition für die de.rec.fotografie und de.alt.rec.digitalfotografie **mit Tabellenausgabe!**

Hilfe zur Benutzung | Download | einfachere Rechner | Hauptseite

(Es passiert nur etwas, wenn Javascript eingeschaltet ist)

Angaben

Bitte verwenden Sie Dezimalpunkt oder Komma. Bei einem Mausklick auf andere Felder, die Blende oder "aktualisieren" werden die Berechnungen aktualisiert

Aufnahmeformat: 13x18cm

Brennweite: [mm] 50

Z-Kreis berechnen

Z-Kreis max.: [mm] 0.02

Beugung einrechnen: Ja / Nein

Naheinstellgrenze: [cm] 0

Gegenstandsweite: m / cm 100

Brechkraft Nahlinse: [dioptrien] 0

Blende: 2.0

x circle of confusion ⇒ few pixel

www.erik-krause.de/schaerfe.htm

Schärfentiefe

Nahpunkt:	98.5cm
Fernpunkt:	1.02m
Bereich:	3.04cm

Bei Einstellung auf die

hyperfokale Distanz von	62.55m
ist alles von	31.28m

bis unendlich scharf

Grenz-Blenden (eingest.)

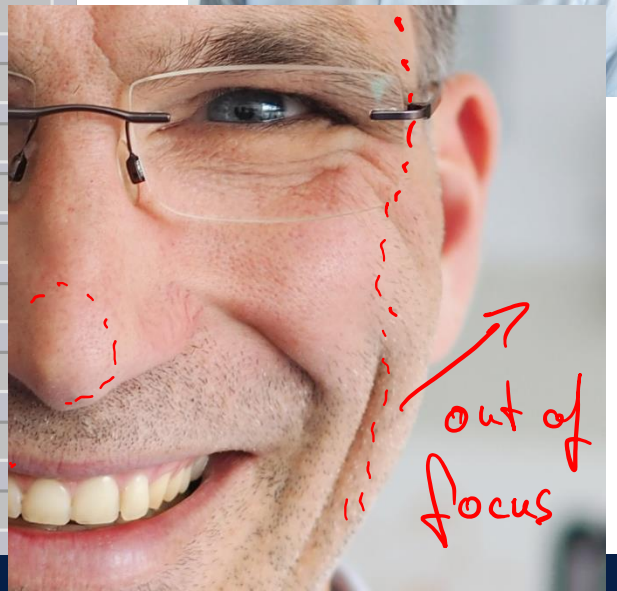
Förderliche:	28.5
Optimale:	5.3

Beugungskreis

bildrelevanter Durchmesser:	0.001mm

Maßstab und Bildgröße

Horiz. Bildwinkel:	119.4°
Vert. Bildwinkel:	102°
Diagon. Bildwinkel:	129.3°
Horiz. Bildfeld:	3.42m
Vert. Bildfeld:	2.47m
Maßstab:	1:19
Effektive Blende:	2.11
Verlängerungs-faktor:	1.11
Auszugsver-längerung:	2.632mm
ca. Entfernung ab Filmebene:	1.05m



Depth of Field

Depth of Field (“Freistellen”)

Depth of Field (“Freistellen”)

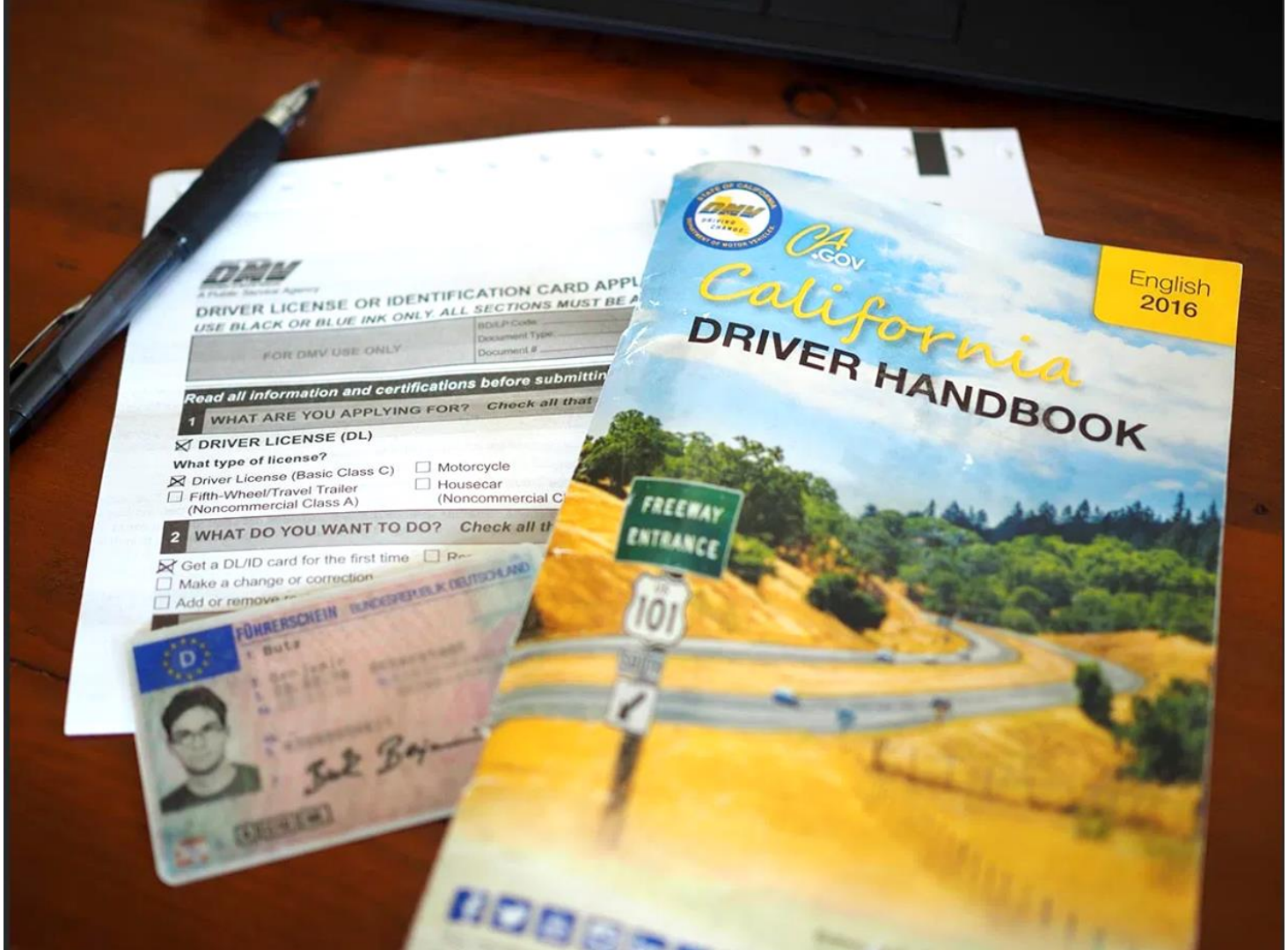
Open Aperture — Bokeh

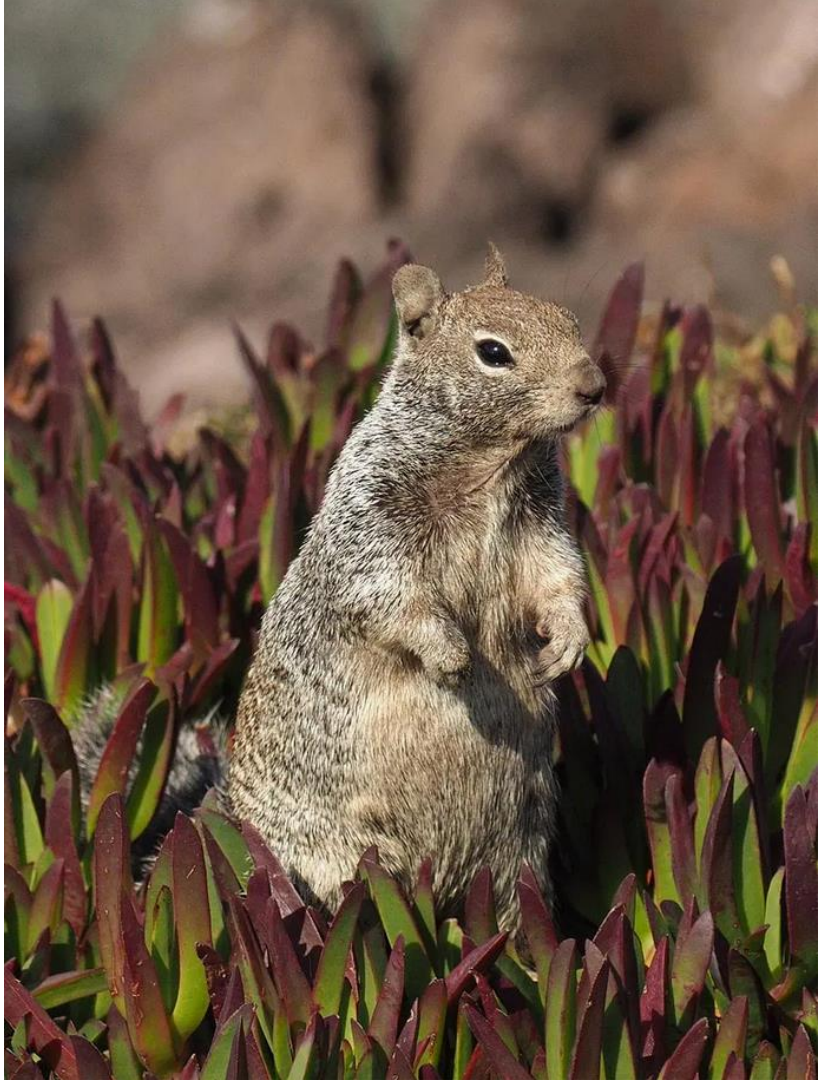
(from jap. 暈け, ぼけ or ボケ, *boke* “blurred, fuzzy”)

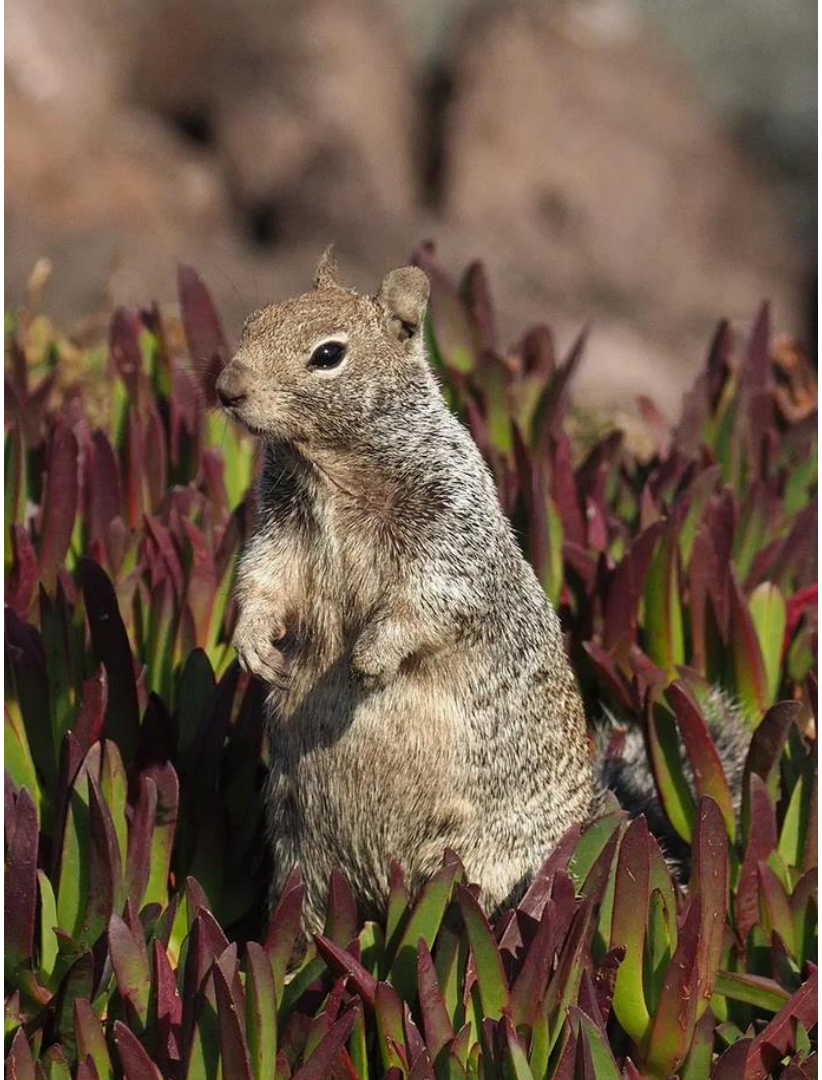
www.myposter.de/magazin/bokeh-effekt-fotografieren/

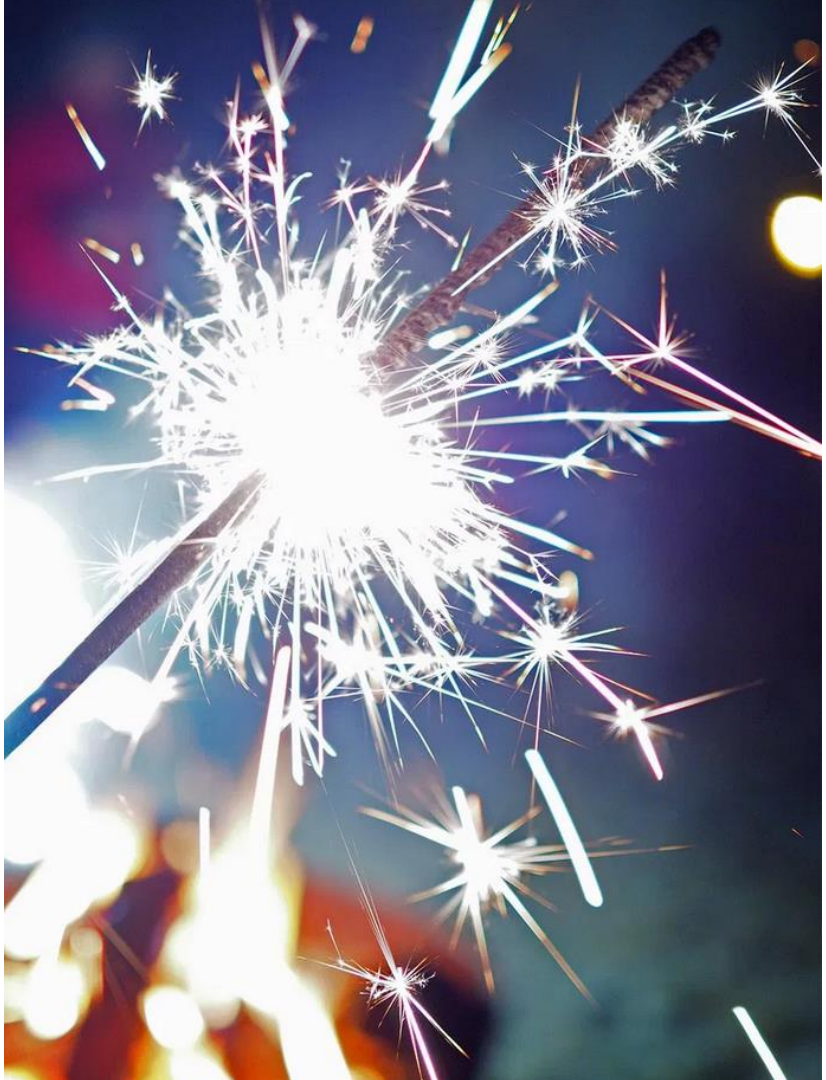
www.hihonor.com

www.otto.de


DMV
DRIVER LICENSE OR IDENTIFICATION CARD APPL
USE BLACK OR BLUE INK ONLY. ALL SECTIONS MUST BE A
FOR DMV USE ONLY
Read all information and certifications before submittin
1 WHAT ARE YOU APPLYING FOR? Check all that
DRIVER LICENSE (DL)
What type of license?
Driver License (Basic Class C)
Fifth-Wheel/Travel Trailer (Noncommercial Class A)
Motorcycle
Housecar (Noncommercial C
2 WHAT DO YOU WANT TO DO? Check all th
Get a DL/ID card for the first time
Make a change or correction
Add or remove
FÜHRERSCHEIN
BUNDESREPUBLIK DEUTSCHLAND
D
CA.GOV
California
DRIVER HANDBOOK
English
2016
FREEWAY
ENTRANCE
101








TAXI
P 040 456

White Balance

Adjusting detector to color temperature of light – White is white!

Routine: capturing almost saturated “white balance” picture
of homogeneous white background (e.g. paper)

Alternative: image processing (adaption of histograms of individual color channels)

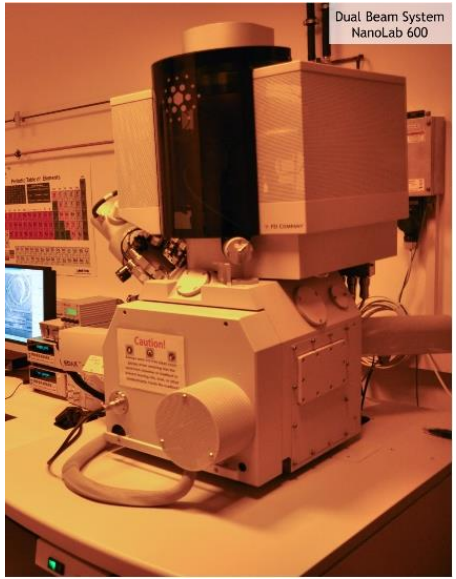
White Balance

Adjusting detector to color temperature of light – White is white!

Routine: capturing almost saturated “white balance” picture
of homogeneous white background (e.g. paper)

Alternative: image processing (adaption of histograms of individual color channels)

original light color



Monitor color temperature adjusted to compensate for white balance correction!

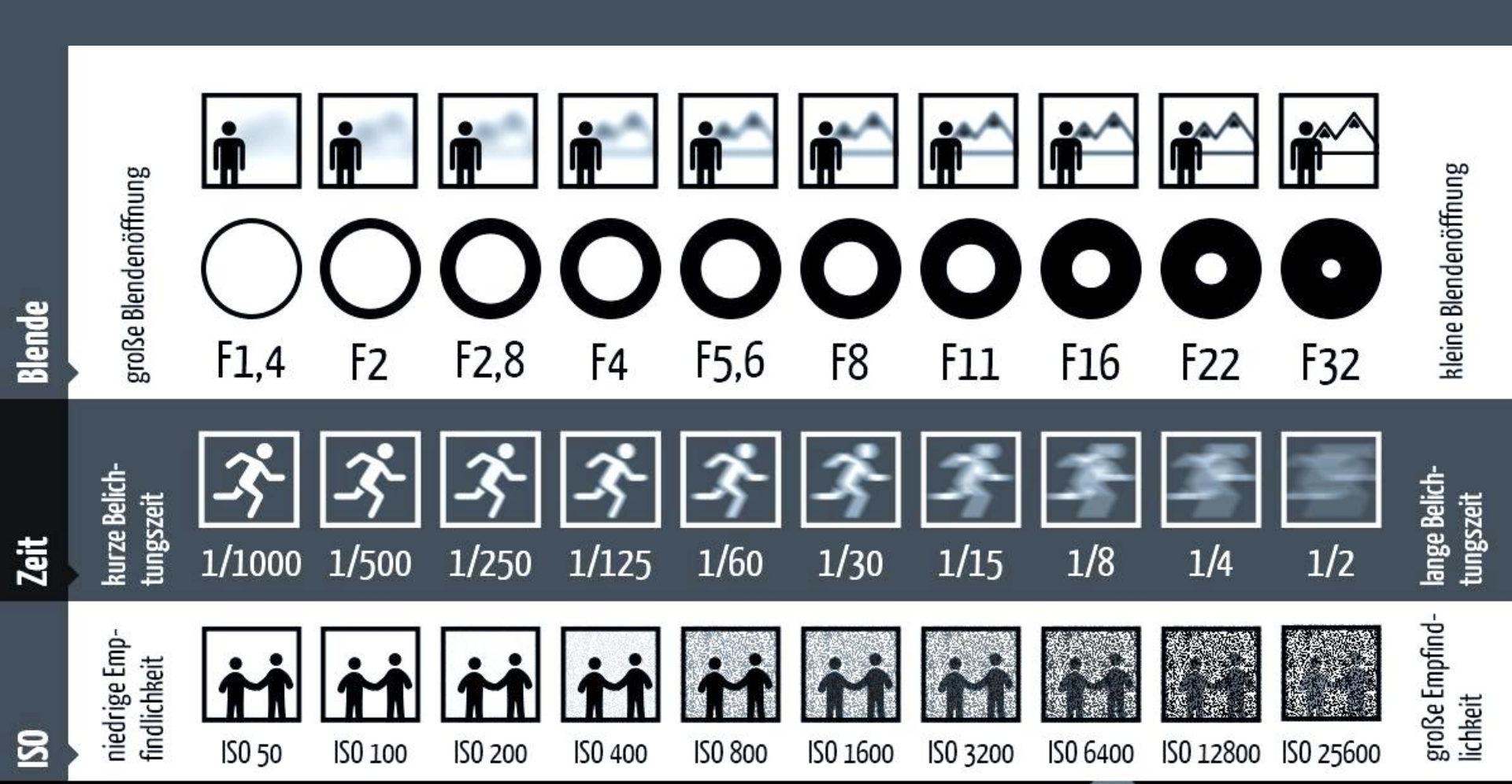


Foto Cheatcard für deine Hosentasche

hamburger-fotospots.de

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PHOTOGRAPHY

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