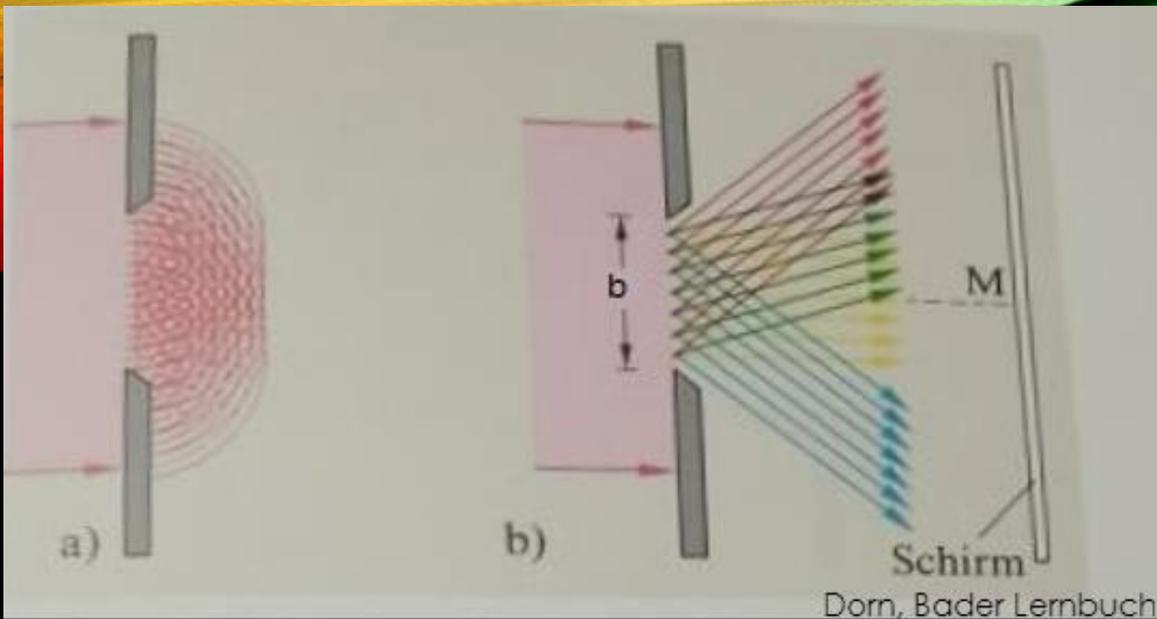


Einsetzen eines auf dem Raspberry Pi
basierten Digitalmesssystems zur
Untersuchung der Beugung am
Einzelspalt

Von Mohammad Al-Hilu
TG13/1

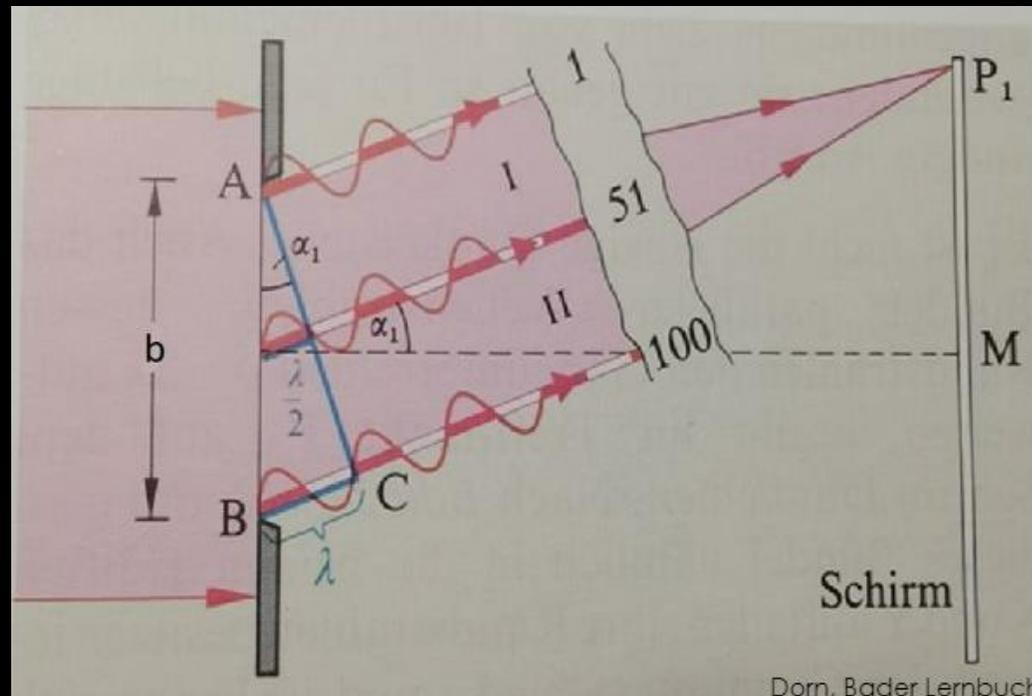
Gliederung

- Ziel des Versuches
- Komponenten und Aufbau des Versuches
- PhyPiDAQ - Konfigurationen: .yaml ; .daq
- Theorie der Beugung am Einzelspalt
- Messwerte
- Auswertung
- Deutung der Ergebnisse



Warum ist $\Delta = K \cdot \lambda$ die Bedingung für Minimum der Beugung am Einzelspalt?????

$\Delta = K \cdot \lambda$ ist eigentlich die Bedingung für Maximum der Interferenz!



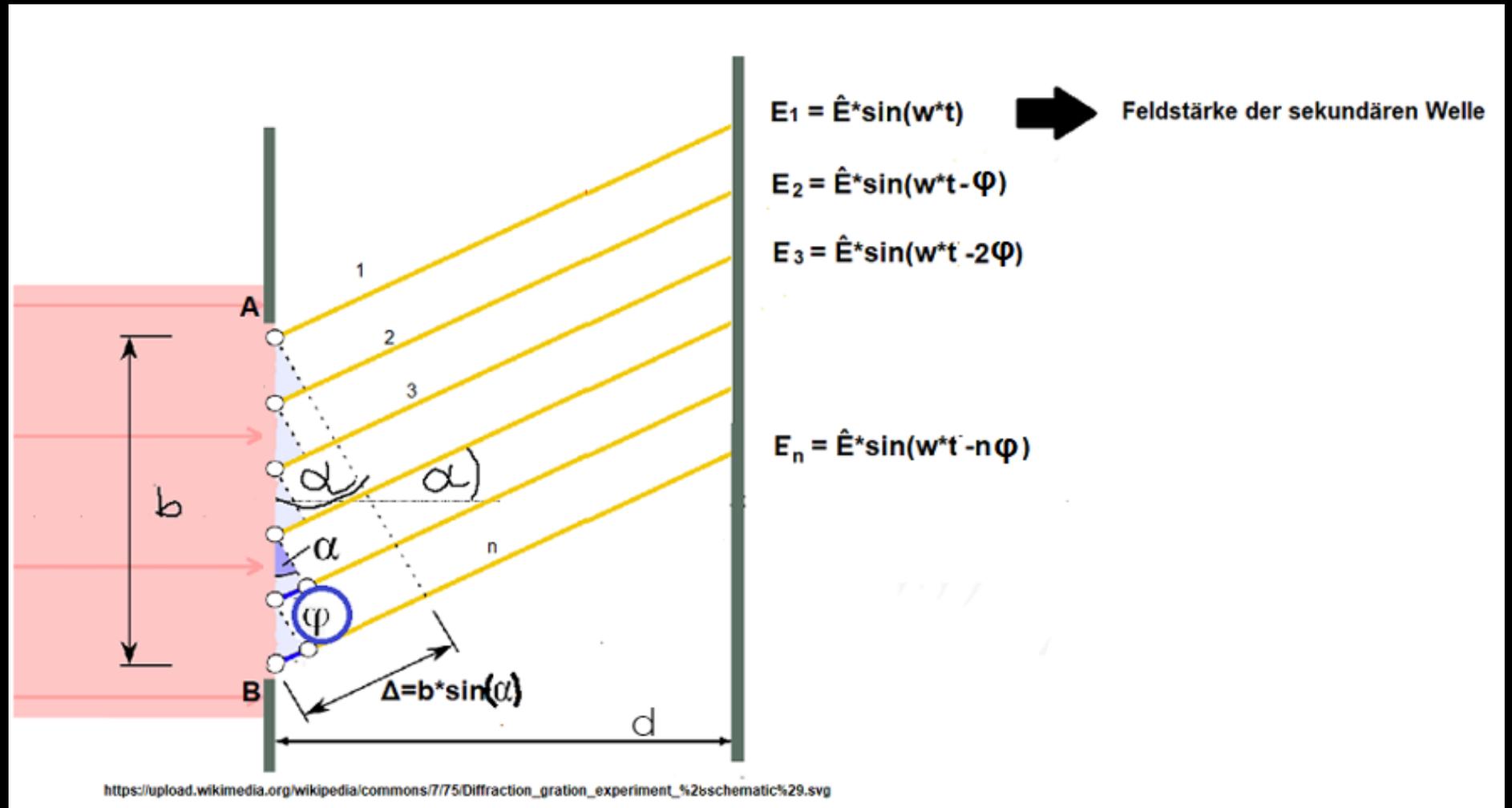
Die zeichnerische Methode vom Lehrbuch erklärt die Verteilung der Intensität am Einzelspalt nicht!!!!!!



ZIEL DES VERSUCHES

(1) Verteilung der Intensität des Lichtes an der Beugungsfigur

Theoretische Grundlagen



$$\frac{\hat{E}_{ges}}{2} = r * \sin (\gamma/2)$$

$$r = \frac{\hat{E}_0}{\gamma}$$

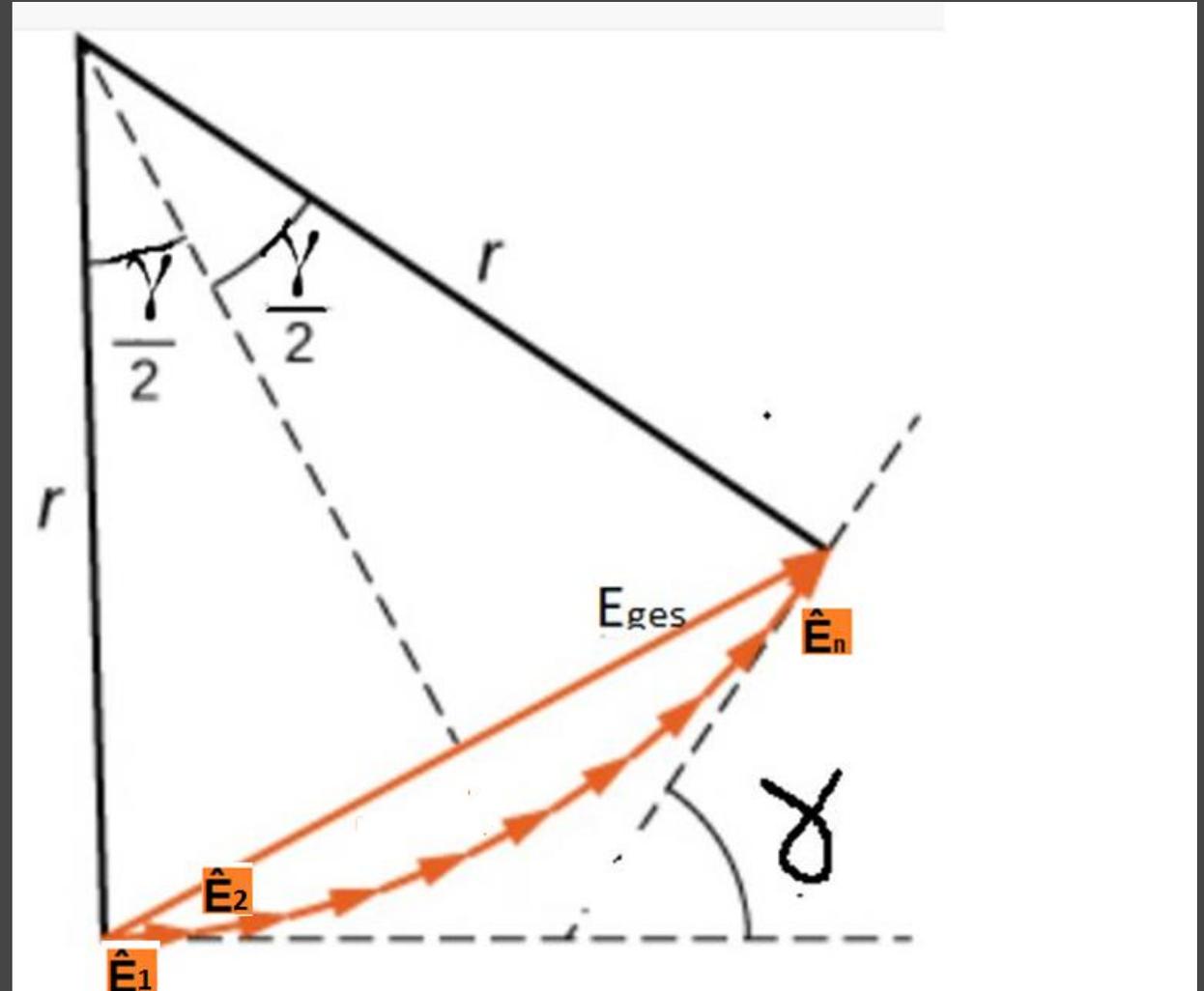
$$\frac{\hat{E}_{ges}}{2} = \frac{\hat{E}_0}{\gamma} * \sin (\gamma/2)$$

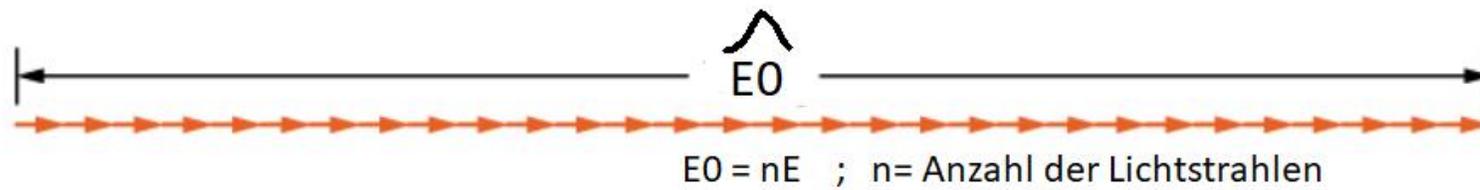
$$\hat{E}_{ges} = \hat{E}_0 * \frac{\sin (\gamma/2)}{(\gamma/2)}$$

$$I \sim W = \frac{\epsilon * E_{ges}^2}{2}$$

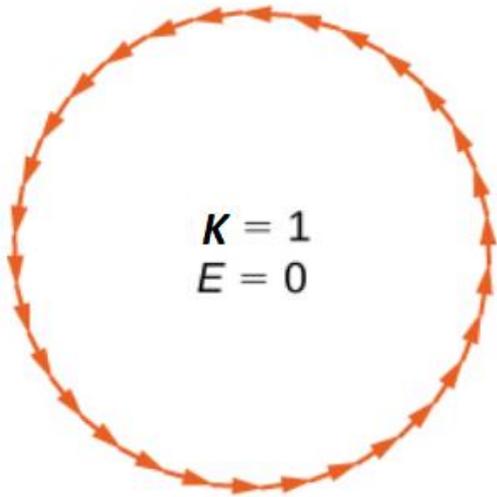
W - transportierte
Energiedichte der em.
Welle

$$I = I_0 * \frac{\sin^2(\gamma/2)}{(\gamma/2)^2}$$

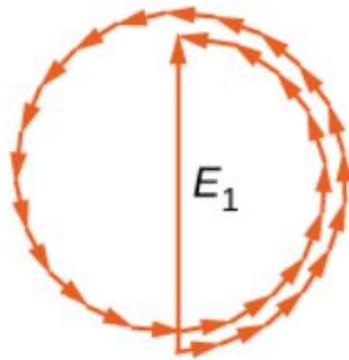




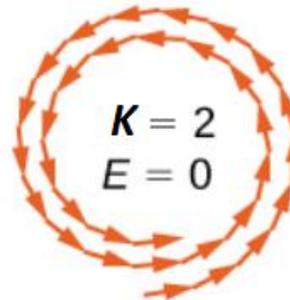
(a)



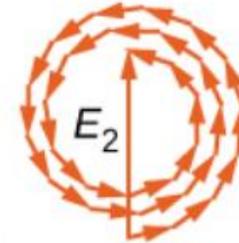
(b)



(c)



(d)

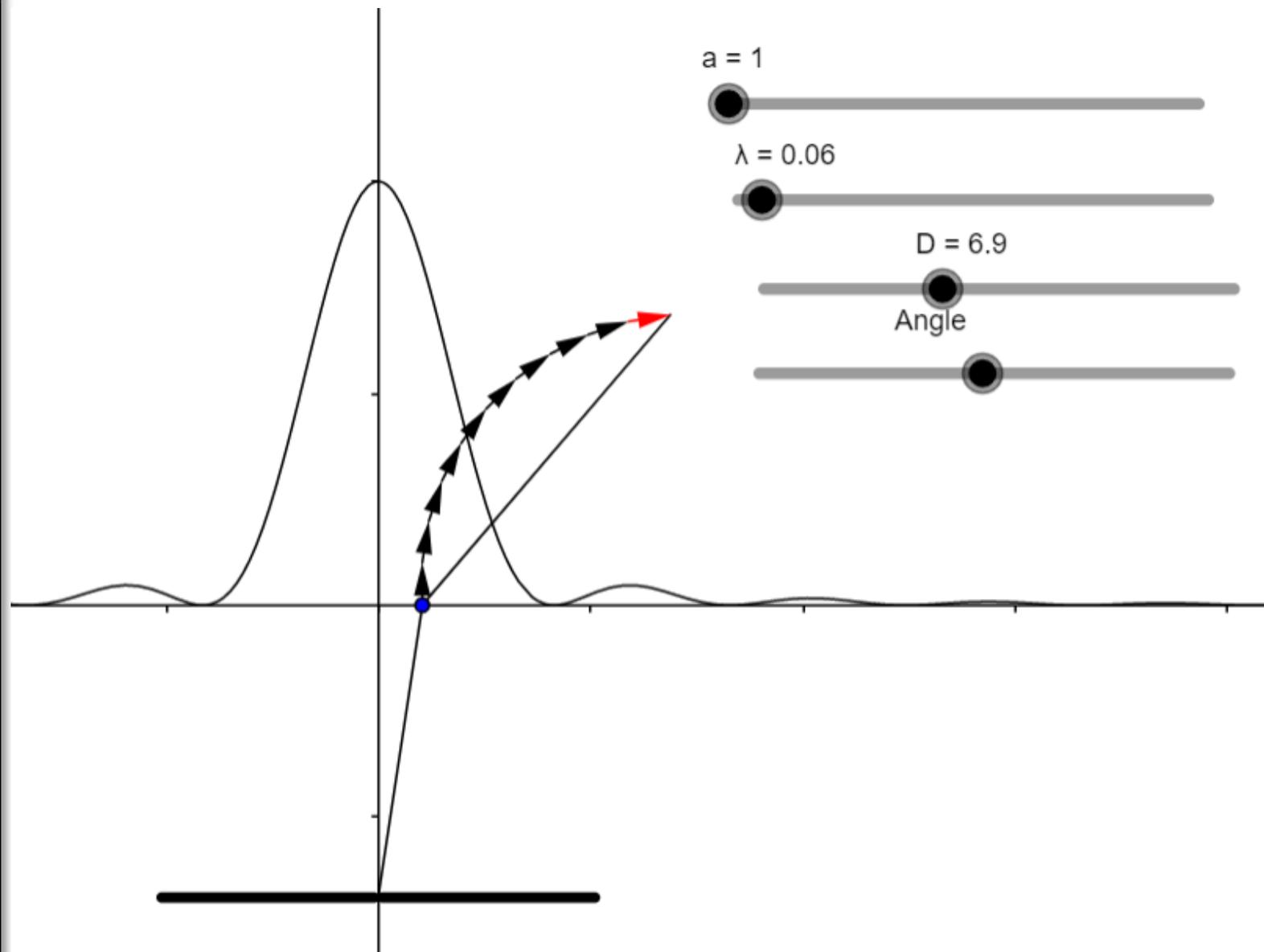


(e)

<https://opentextbc.ca/universityphysicsv3openstax/chapter/intensity-in-single-slit-diffraction/>

- (a) - Hauptmaximum
- (b) - erste Minimum
- (c) - erste Maximum nach dem Hauptmaximum
- (d) - zweite Minimum
- (e) - zweite Maximum nach dem Hauptmaximum

- <https://www.geogebra.org/m/g2wftduq>



$$I = I_0 \cdot \frac{\sin^2(\pi/\lambda \cdot b \cdot \sin(\alpha))}{(\pi/\lambda \cdot b \cdot \sin(\alpha))^2}$$

$$\Delta = b \cdot \sin(\alpha) \quad \xrightarrow{1.}$$

$$\gamma = \frac{2\pi\Delta}{\lambda} \quad \xrightarrow{2.}$$

$$\Delta = K \cdot \lambda$$

$$\xrightarrow{3.} I = I_0 \cdot \frac{\sin^2((2\pi\Delta/\lambda) \cdot 1/2)}{((2\pi\Delta/\lambda) \cdot 1/2)^2} = I_0 \cdot \frac{\sin^2(\pi\Delta/\lambda)}{(\pi\Delta/\lambda)^2}$$

Minima

$\Delta = K \cdot \lambda$ - Bedingung für Maximum der Interferenz

$$K=1$$

$$I_{\min 1} = I_0 \cdot \frac{\sin^2(\pi/\lambda \cdot 1 \cdot \lambda)}{(\pi/\lambda \cdot 1 \cdot \lambda)^2}$$

$$\Rightarrow I_{\min 1} = I_0 \cdot 0 / = 0$$

Maxima

$$K=0$$

$$\Delta = 0 \cdot \lambda$$

$$I = I_0 \cdot \frac{\sin^2((\pi/\lambda) \cdot 0 \cdot \lambda \cdot 1/2)}{((\pi/\lambda) \cdot 0 \cdot \lambda \cdot 1/2)^2} = I_0 \cdot \frac{\sin^2(0)}{(0)^2} = I_0 \cdot 1$$

$$I = I_0$$

Minima

$$K=2$$

$$\Delta = 2 * \lambda$$

$$I_{\min 2} = I_0 * \frac{\sin^2(\pi/\lambda * 2 * \lambda)}{(\pi/\lambda * 2 * \lambda)^2}$$

$$\Rightarrow I_{\min 2} = I_0 * 0/4\pi^2 = 0$$

$$K=3$$

$$\Delta = 3 * \lambda$$

$$I_{\min 3} = I_0 * \frac{\sin^2(\pi/\lambda * 3 * \lambda)}{(\pi/\lambda * 3 * \lambda)^2}$$

$$\Rightarrow I_{\min 2} = I_0 * 0/9\pi^2 = 0$$

Maxima

$$\Delta = (2K+1) * \lambda / 2$$

- für Maxima der Beugung

$$K=1$$

$$I_{\max 1} = I_0 * \frac{\sin^2((\pi/\lambda (2 * 1 + 1) * \lambda / 2))}{((\pi/\lambda (2 * 1 + 1) * \lambda / 2))^2}$$

$$I_{\max 1} = I_0 * \frac{\sin^2(3\pi/2)}{(3\pi/2)^2} = I_0 * \frac{1}{(3\pi/2)^2}$$

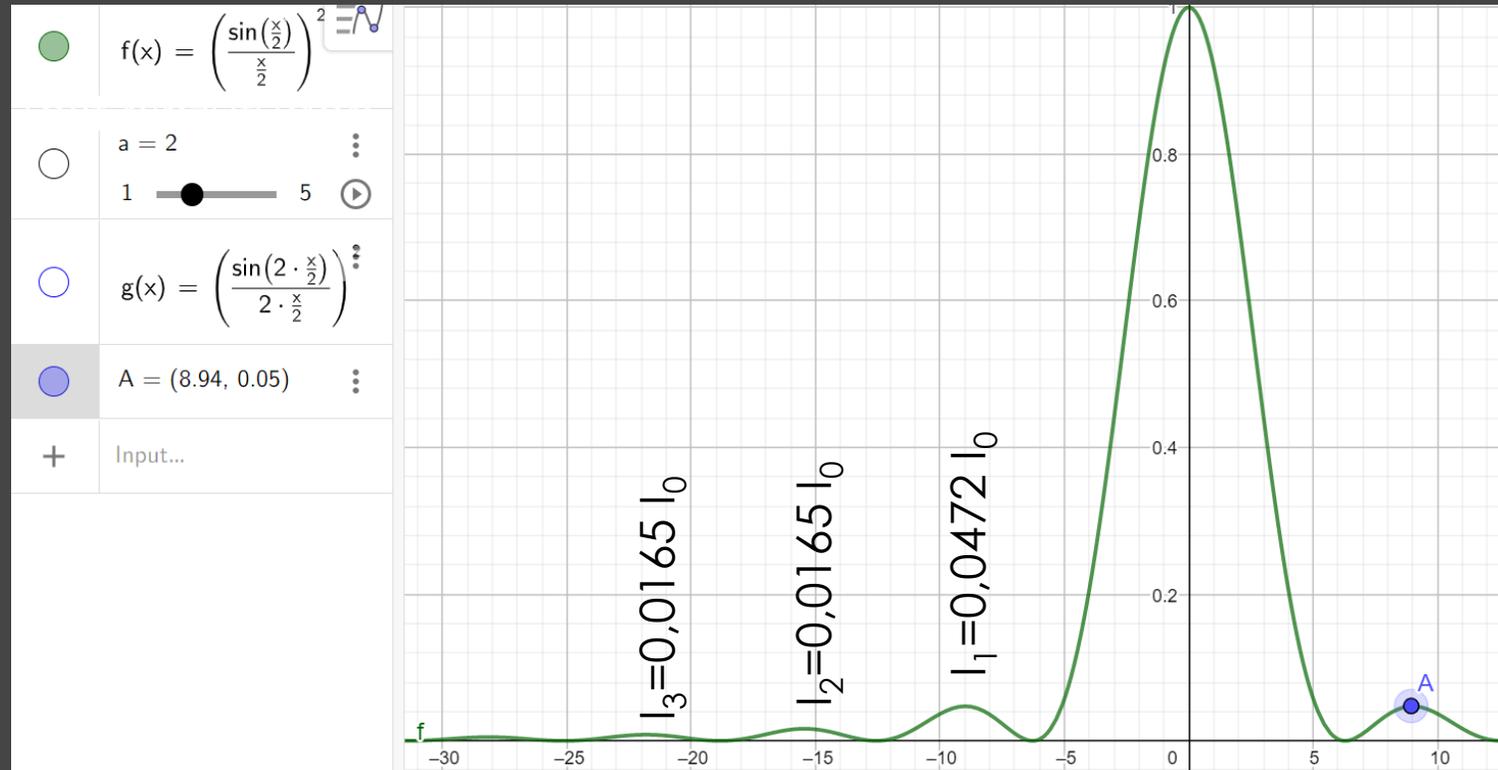
Theoretische Bestimmung der Intensität der Maxima

$$I = I_0 \frac{\sin^2(\gamma/2)}{(\gamma/2)^2}$$

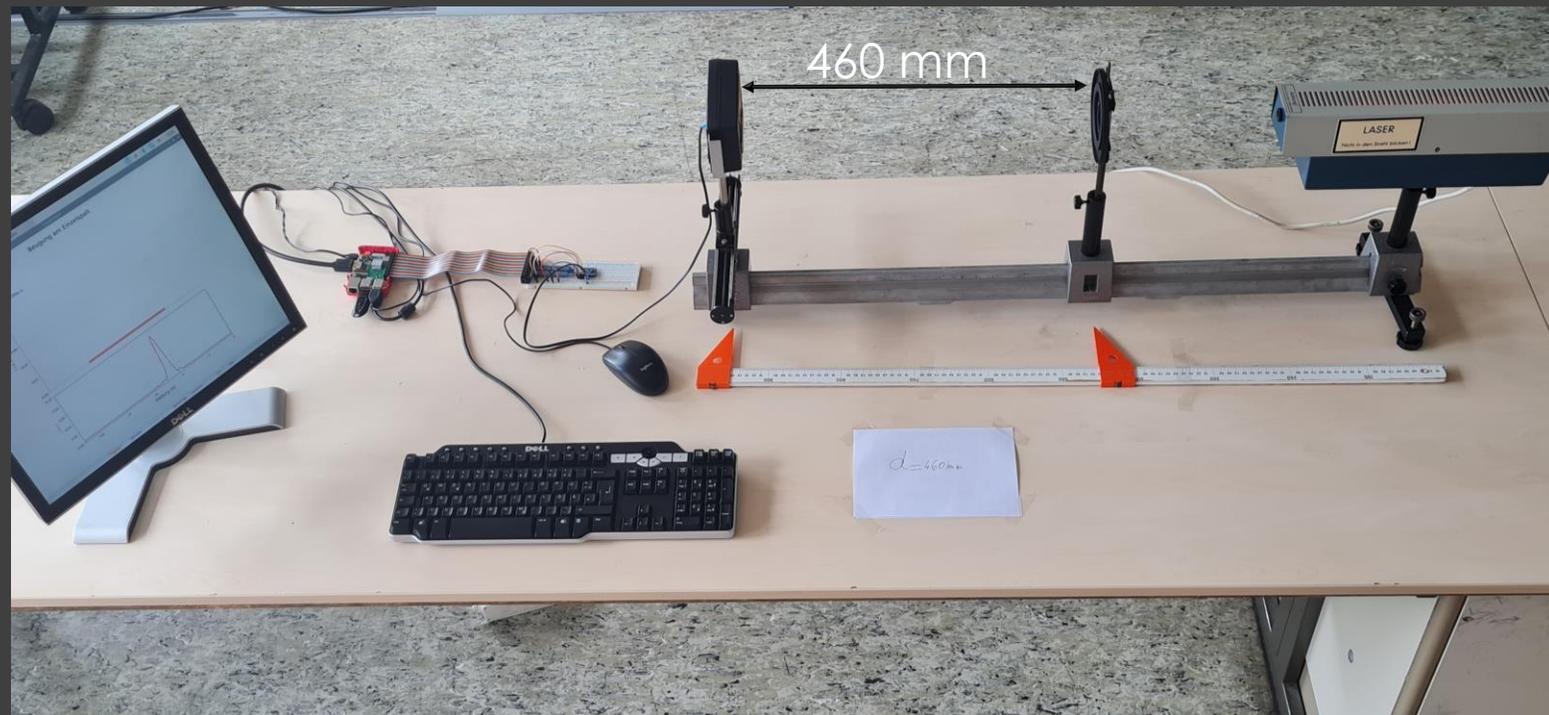


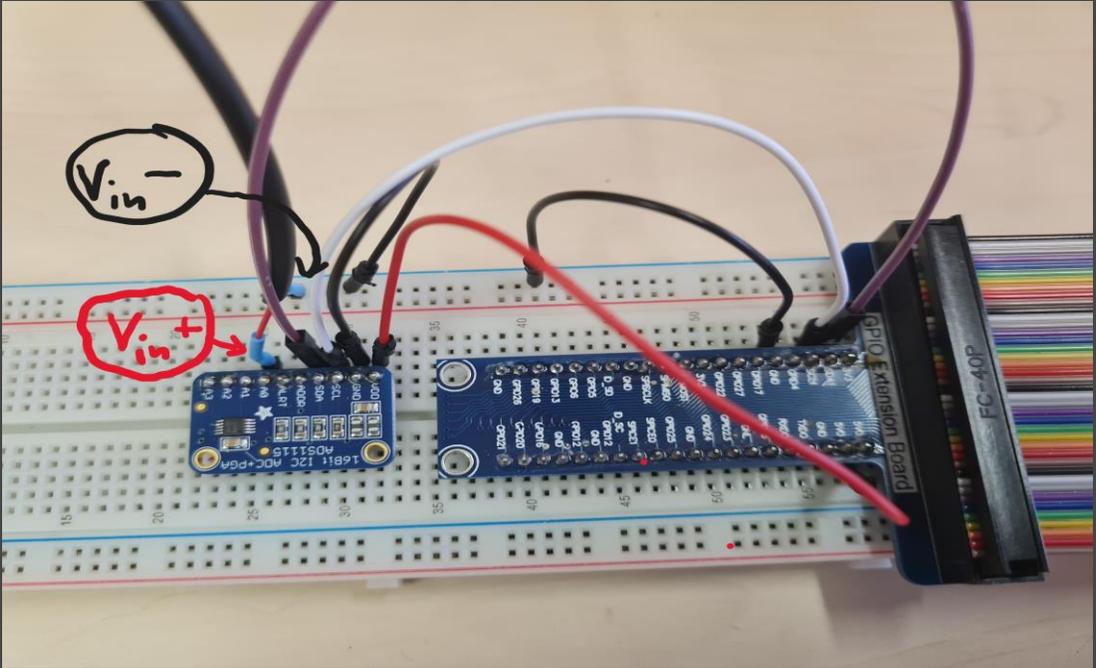
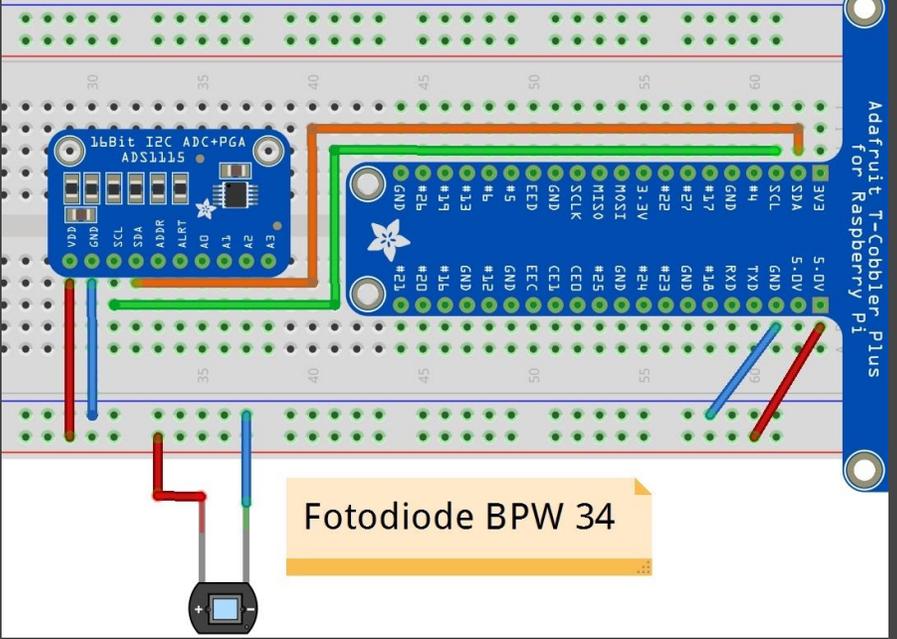
K	1	2	3	4
I_{\max_k}/I_0 in %	$\frac{1}{(3\pi/2)^2}$	$\frac{1}{(5\pi/2)^2}$	$\frac{1}{(7\pi/2)^2}$	$\frac{1}{(9\pi/2)^2}$
	0,0472	0,0165	0,0083	0,005

Einsatz der GeoGebra zur
Untersuchung der theoretischen
Verteilung der Intensität des Lichts



Aufbau des Versuches





KOMPONENTEN DES VERSUCHES

**BPW 34 Silizium-PIN-Fotodiode,
50 μ A / 430...1100nm**



Leistung:	0,215 W
Länge:	4,65 mm
Höhe:	2 mm
Breite:	4,3 mm
Temperaturbereich:	-40 ... +100°C
Hersteller:	VISHAY
Stromstärke:	50 μ A
Wellenlänge:	430 ... 1100nm

.yaml

```
# example of a configuration file for ADC ADS1115

DAQModule: ADS1115Config

ADCChannels: [0]      # active ADC-Channels
                      # possible values: 0, 1, 2, 3
                      # when using differential mode:
                      # - 0 = ADCChannel 0
                      #   minus ADCChannel 1
                      # - 1 = ADCChannel 0
                      #   minus ADCChannel 3
                      # - 2 = ADCChannel 1
                      #   minus ADCChannel 3
                      # - 3 = ADCChannel 2
                      #   minus ADCChannel 3

DifModeChan: [false] # enable differential mode for Channels
Gain: [2/3]          # programmable gain of ADC-Channel
                    # possible values for Gain:
                    # - 2/3 = +/-6.144V
                    # - 1 = +/-4.096V
                    # - 2 = +/-2.048V
                    # - 4 = +/-1.024V
                    # - 8 = +/-0.512V
                    # - 16 = +/-0.256V

sampleRate: 860      # programmable Sample Rate of
ADS1115
                    # possible values for

SampleRate:
860
```

.daq

```
# -- Configuration Options for PhyPiDAQ
# -----

#
# -- configuration files for hardware devices
#
#DeviceFile: config/ReplayConfig.yaml      # data from File
#optional:
#DeviceFile: config/ToyDataConfig.yaml    # simulated data

# other options (requires connected hardware):
DeviceFile: config/ADS1115Config.yaml     # 16 bit ADC, I2C bus
#DeviceFile: config/MCP3008Config.yaml    # 10 bit ADC, SPI bus
#DeviceFile: config/MCP3208Config.yaml    # 12 bit ADC, SPI bus
#DeviceFile: config/PSConfig.yaml        # PicoTechnology USB
scope
#DeviceFile: config/MAX31865Config.yaml   # Pt 100 sensor
#DeviceFile: config/GPIOCCount.yaml      # frequency count
#DeviceFile: config/DS18B20Config.yaml   # digital temperature
sensor
#DeviceFile: config/MAX31855Config.yaml   # thermo element
#DeviceFile: config/BMP180Config.yaml    #
pressure/temperature sensor
#DeviceFile: config/INA219Config.yaml    # Voltage/Current
sensor
#DeviceFile: config/MMA845xConfig.yaml   # Accelerometer

## an example of multiple devices
#DeviceFile: [config/ADS1115Config.yaml,
config/GPIOCCount.yaml]
```

```
#
# -- configuration options for Channels
#
#ChanLabels: ['X1', 'X2']          # names for channels
ChanUnits: ['a.U.']              # units for channels
#ChanLabels: [U, U]              # names for channels
#ChanUnits: [V, V]              # units for channels
ChanNams: [I]
ChanColors: [red, sienna]       # channel colours in display

# eventually overwrite Channel Limits obtained from device
config
ChanLimits:
- [0., 0.1] # chan 0, Y-Achse Skalierung
## - [0., 1.] # chan 1
## - [0., 1.] # chan 2

# calibration of channel values
# - null or - <factor> or - [ [ <>true values> ], [ <raw
values> ] ]
#ChanCalib:
# - 1. # chan0: simple calibration
factor
# - [ [0.,1.], [0., 1.] ] # chan1: interpolation: [true]
([<raw>] )
# - null # chan2: no calibration

# apply formulae to (calibrated) channel values
ChanFormula:
- c0 + 0.006 # chan0, die Maxima höhere Ordnungen sind seh
klein
# - c1 # chan1
# - null # chan2 : no formula
```

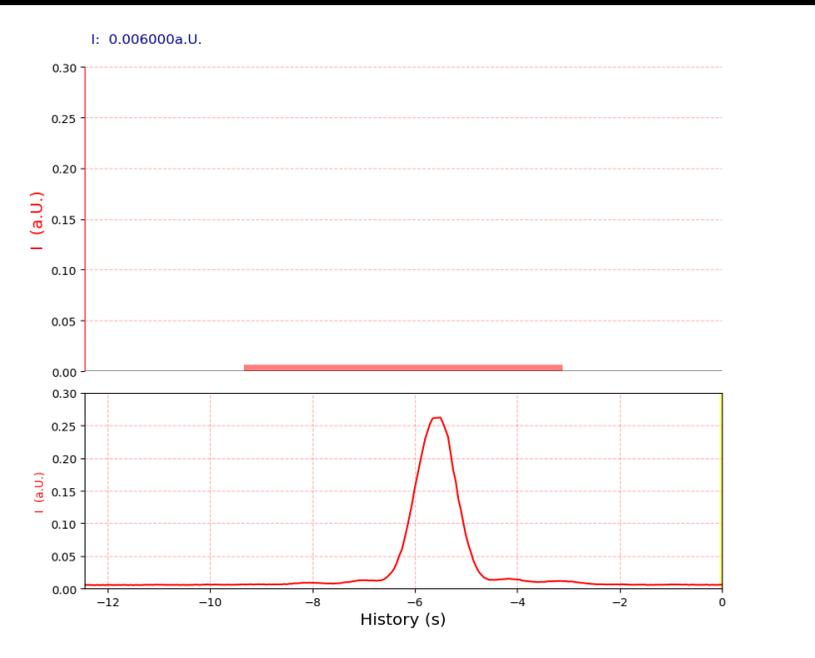
```
#
# -- configuration options for graphical display
#
Interval: 0.05 # logging interval
NHistoyPoints: 420 # number of points used in
history buffer
#DisplayModule: DataLogger # history of channel signals
DisplayModule: DataGraphs # text, bar-graph, history and
#xy-view
Title: "Beugung am Einfachspalt" # display title
#XYmode: Data from File false # enable/disable
#XY-display false
## if more than two channels active:
#Chan2Axes: [0, 1, 0] # assign channels to axes
#xyPlots: # define which axes to show
# - [0, 1] # in xy-plot
# - [0, 2]
# - [1, 2]

#
# -- configuration options for output to file
#
DataFile: testfile.csv # file name for output file,
#DataFile: null # null to disable
CSVseparator: ';' # field separator, set to ';' for
German Excel

# enable buffering of latest data (depth NHistoyPoints from
above)
#bufferData: PhyPiData # file name to track latest data and
eventually
#bufferData: null # store them, or null to switch off

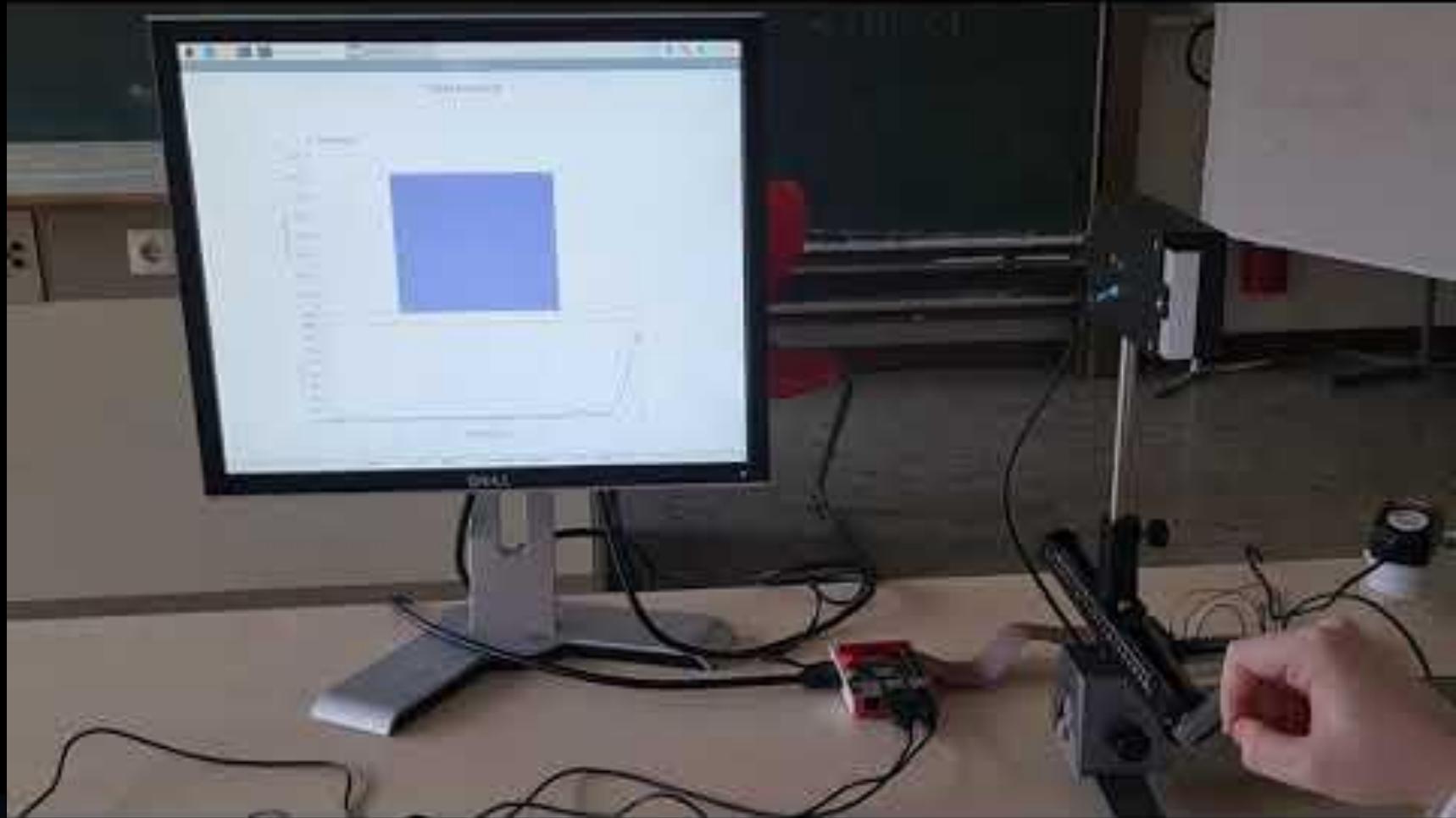
# control status LEDs
#RunLED: 20 # display run status on GPIO pin 20
#ReadoutLED: 21 # display readout on GPIO pin 21
```

Aufzeichnung der Beugungsfigur in Echtzeit



Gespeichertes Bild der
Intensitätsverteilung des Lichts
am Einzelspalt

[Video des Versuchs](#)



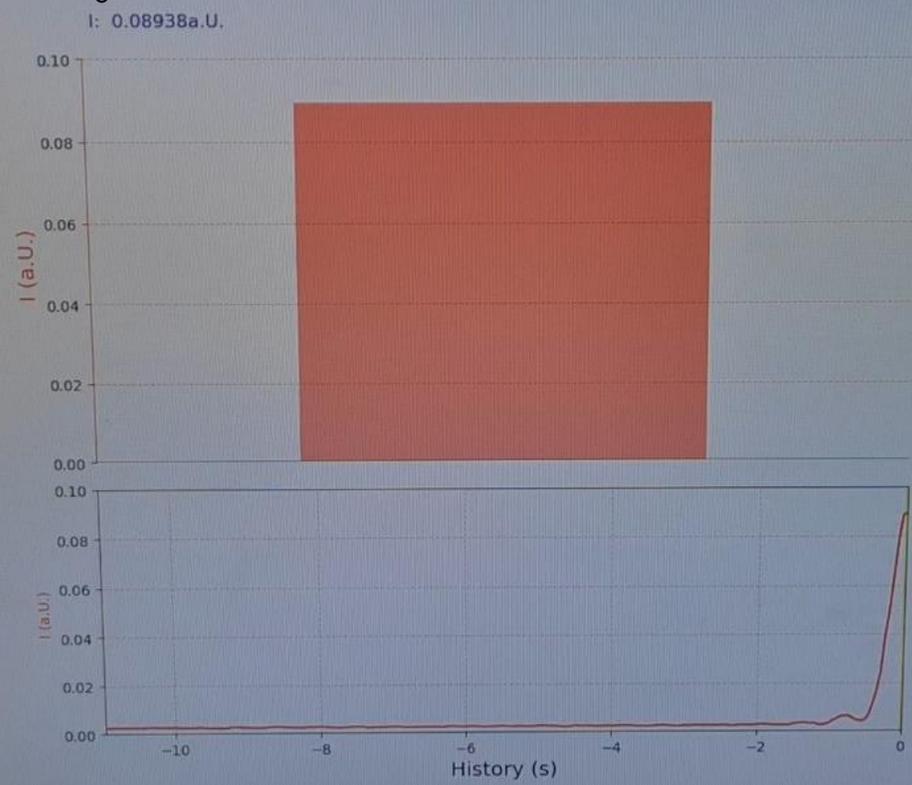
Beugung am Einzelspalt

$$I_1 = 0,004292$$



Beugung am Einzelspalt

$$I_0 = 0,08938$$



Experimenteller Wert: $I_1/I_0 = 0,04801$

Theoretisch: $I_1/I_0 = 0,04712$

	A	B	C	D
58	0.004134	2.7	0.004134	
59	0.004507	2.75	0.004507	
60	0.004321	2.8	0.004321	
61	0.004134	2.85	0.004134	
62	0.004134	2.9	0.004134	
63	0.004694	2.95	0.004694	
64	0.005254	3	0.005254	
65	0.004694	3.05	0.004694	
66	0.00488	3.1	0.00488	
67	0.005254	3.15	0.005254	
68	0.005254	3.2	0.005254	
69	0.00488	3.25	0.00488	
70	0.005254	3.3	0.005254	
71	0.00544	3.35	0.00544	
72	0.005254	3.4	0.005254	
73	0.004507	3.45	0.004507	
74	0.005067	3.5	0.005067	
75	0.00544	3.55	0.00544	
126	0.07355	6.1	0.07355	
127	0.08045	6.15	0.08045	
128	0.0812	6.2	0.0812	
129	0.08064	6.25	0.08064	
130	0.08213	6.3	0.08213	
131	0.08474	6.35	0.08474	
132	0.08829	6.4	0.08829	
133	0.08101	6.45	0.08101	
134	0.08157	6.5	0.08157	
135	0.08008	6.55	0.08008	
136	0.07858	6.6	0.07858	
137	0.08176	6.65	0.08176	
138	0.07541	6.7	0.07541	

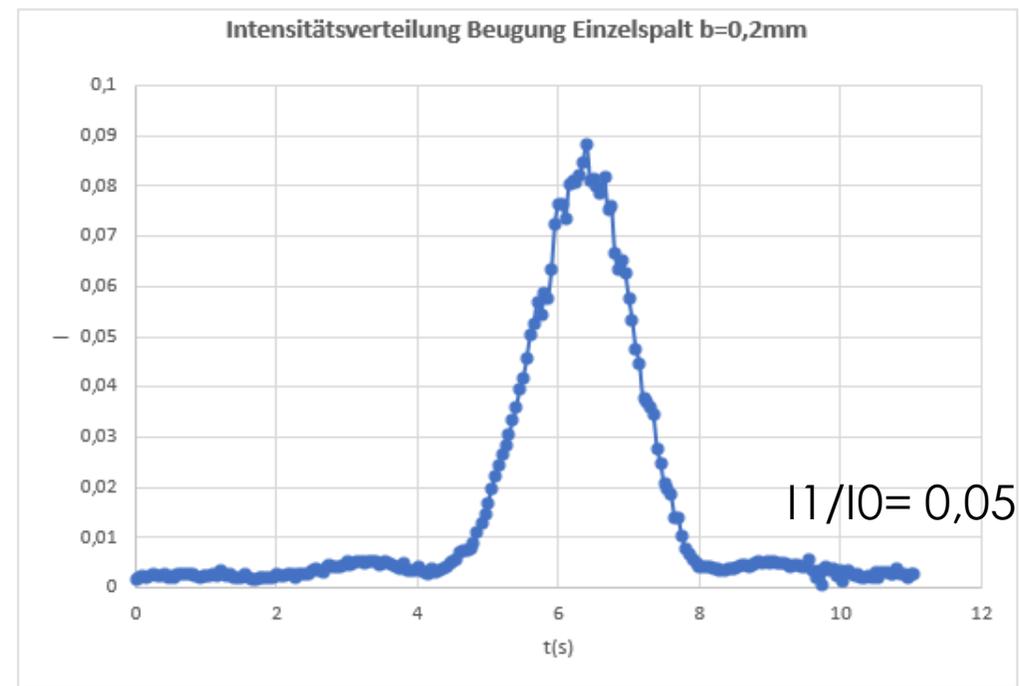
11



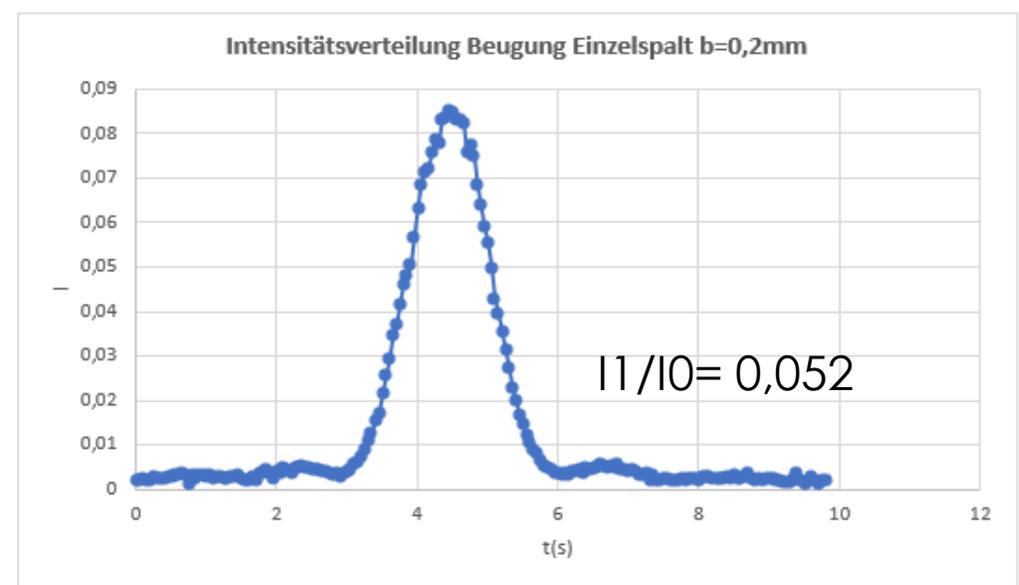
10



Auswertung aus den in .csv-Format gespeicherten echten Messdaten



Messdaten aus testfile_200222-1124+.csv



Messdaten aus testfile_200222-1124+.csv



VIELEN DANK FÜR
IHRE
AUFMERKSAMKEIT