V64

Interferometry

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Durchführung: DATUM

Abgabe: DATUM

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Inhaltsverzeichnis

1 Theorie

[**sample**]

2 Durchführung

3 Analysis

3.1 Kontrast

In order to study the usage of interferrometrie to determine refraction indices, first of all the kontrast of the used Sagnac Interferometer was calculated. The kontrast was calculated with equation (**??**) and the values of table 1. Table 1 also contains the calculated kontrast values. The maximum contrast K = 0.92 was measured at $\Phi = 130°$ Therefore the polarization filter was set to $\Phi = 130°$ for the following measurements. In addition, a fit of the form

$$K = A \cdot |\cos(\Phi)\sin(\Phi)| \tag{1}$$

is performed with the mean values of the measured values. This can be seen for the determined value of $A = 1.76 \pm 0.07$ in graph 1.

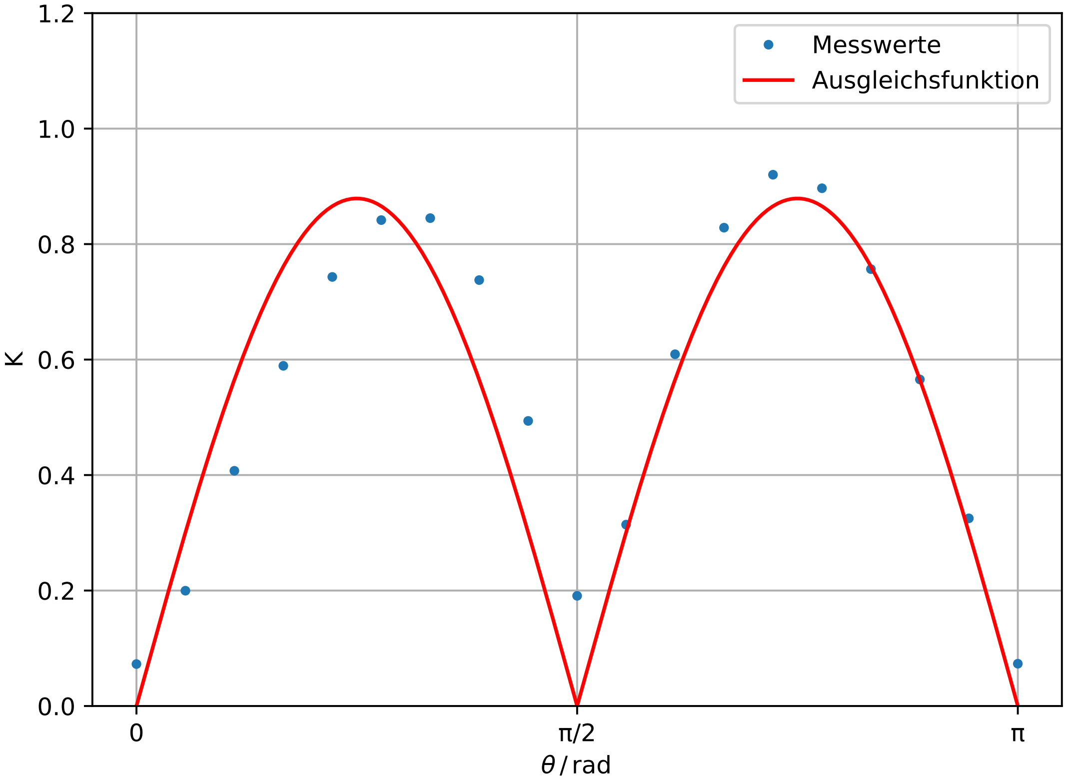

Abbildung 1: The measured values of the contrast according to equation (**??**) and the fit calculation according to equation (**??**).

Tabelle 1: Recorded measured values for contrast measurement, as well as the respective contrast value.

$\Phi/°$	$U_{\mathrm{min},1}/\mathrm{V}$	$U_{\mathrm{max},1}/\mathrm{V}$	K_1	$U_{\mathrm{min},2}/\mathrm{V}$	$U_{\mathrm{max},2}/\mathrm{V}$	K_2	$U_{\mathrm{min},3}/\mathrm{V}$	$U_{\mathrm{max},3}/\mathrm{V}$	K_3
0	1.73	1.98	0.06	1.8	2.1	0.07	1.76	2.04	0.07
10	1.21	1.8	0.19	1.16	1.78	0.21	1.24	1.83	0.19
20	0.69	1.65	0.41	0.7	1.63	0.39	0.69	1.66	0.41
30	0.36	1.44	0.60	0.39	1.46	0.57	0.38	1.47	0.58
40	0.21	1.48	0.75	0.23	1.47	0.72	0.21	1.46	0.74
50	0.14	1.7	0.84	0.15	1.64	0.83	0.14	1.66	0.84
60	0.17	1.98	0.84	0.16	1.93	0.84	0.16	1.92	0.84
70	0.37	2.35	0.72	0.32	2.15	0.74	0.33	2.25	0.74
80	0.85	2.36	0.47	0.7	2.22	0.52	0.79	2.31	0.49
90	1.64	2.36	0.18	1.48	2.28	0.21	1.62	2.33	0.17
100	1.43	2.93	0.34	1.46	2.68	0.29	1.49	2.79	0.30
110	1.08	4.13	0.58	0.92	3.78	0.60	0.91	4.06	0.63
120	0.52	5.06	0.81	0.49	5.06	0.82	0.44	5.36	0.84
130	0.24	5.53	0.91	0.25	5.56	0.91	0.21	5.76	0.92
140	0.34	5.92	0.89	0.33	5.91	0.89	0.3	5.99	0.90
150	0.73	5.26	0.75	0.77	5.39	0.75	0.73	5.45	0.76
160	1.16	4.13	0.56	1.22	4.25	0.55	1.16	4.38	0.58
170	1.63	3.18	0.32	1.67	3.19	0.31	1.62	3.29	0.34
180	1.86	2.08	0.05	1.85	2.18	0.08	1.79	2.11	0.08

3.2 Refraction index of glas

To determine the refractive index of glass, the number of intensity maxima M was recorded. The refractive index was determined using the equation (**??**). The thickness of the plates is $D = 1$ mm, the wavelength of the laser $\lambda_0 = 632.990$ nm and $\Omega_0 = 10°$ as the two plates are each Ω_0 inclined. The measured values, as well as the refractive index determined in each case, can be found in Table 2. On average, the refractive index determined for glass is

$$n_{\mathrm{Glas}} = 1.64 \pm 0.13.$$

Tabelle 2: AMeasured values to determine the refractive index of glass and the determined refractive index.

Durchgang	M	n_{Glas}
1	38	1.652392
2	38	1.652392
3	38	1.652392
4	37	1.624503
5	38	1.652392
6	38	1.652392
7	37	1.624503
8	38	1.652392
9	38	1.652392
10	37	1.624503

3.3 Refraction index of air

To determine the refractive index of air, the measured values were recorded as described in chapter **??** and determined using equation **??**. The length of the gas chamber is L = (100.0 ± 0.1) mm and the temperature T = 20.6 °C . The recorded values as well as the calculated reflection indices are shown in Table 3.

Tabelle 3: Measured values recorded to determine the refractive index of air next to the refractive index calculated according to equation (**??**). Here, M_i denotes the number of interference minima or maxima that have passed up to that point, where i indicates the passage.

p/mbar	M_1	n_1	M_2	n_2	M_3	n_3	M_4	n_4
50	2	1,000 012 66	2	1,000 012 66	2	1,000 012 66	3	1,000 018 99
100	4	1,000 025 32	4	1,000 025 32	4	1,000 025 32	5	1,000 031 65
150	7	1,000 044 31	6	1,000 037 98	6	1,000 037 98	7	1,000 044 31
200	9	1,000 056 97	8	1,000 050 64	8	1,000 050 64	9	1,000 056 97
250	11	1,000 069 63	10	1,000 063 30	10	1,000 063 30	11	1,000 069 63
300	13	1,000 082 29	12	1,000 075 96	12	1,000 075 96	13	1,000 082 29
350	15	1,000 094 95	15	1,000 094 95	15	1,000 094 95	15	1,000 094 95
400	17	1,000 107 61	17	1,000 107 61	17	1,000 107 61	18	1,000 113 94
450	20	1,000 126 60	19	1,000 120 27	19	1,000 120 27	20	1,000 126 60
500	22	1,000 139 26	21	1,000 132 93	21	1,000 132 93	22	1,000 139 26
550	24	1,000 151 92	23	1,000 145 59	23	1,000 145 59	24	1,000 151 92
600	26	1,000 164 58	25	1,000 158 25	25	1,000 158 25	26	1,000 164 58
650	28	1,000 177 24	27	1,000 170 91	27	1,000 170 91	28	1,000 177 24
700	30	1,000 189 90	30	1,000 189 90	29	1,000 183 57	30	1,000 189 90
750	32	1,000 202 56	31	1,000 196 23	32	1,000 202 56	33	1,000 208 89
800	35	1,000 221 55	34	1,000 215 22	34	1,000 215 22	35	1,000 221 55
850	37	1,000 234 21	36	1,000 227 88	36	1,000 227 88	37	1,000 234 21
900	39	1,000 246 87	38	1,000 240 54	38	1,000 240 54	39	1,000 246 87
950	41	1,000 259 53	40	1,000 253 20	40	1,000 253 20	41	1,000 259 53

3.4 Lorentz-Lorenz law

Since the refractive index also dependents on temperature and pressure according to the Lorentz-Lorenz law, an fit calculation is carried out according to equation **??** . The fit has the form

$$n = \frac{a}{TR} \cdot p + b \tag{2}$$

The temperate is T = 20.6 °C and R describes the universal gas constant. This results in the in table 4 shown values for a and b.

Tabelle 4: The results of the fit for the variables a and b for each run.

Messung	$a/\left(10^{-2}\mathrm{m}^3/\mathrm{mol}\right)$	b
1	0.00066776 ±0.00000394	1.00000056 ±0.00000092
2	0.00065800 ±0.00000397	0.99999789 ±0.00000093
3	0.00065854 ±0.00000364	0.99999778 ±0.00000085
4	0.00066017 ±0.00000370	1.00000344 ±0.00000086

The fits and thus the calculated refractive indices are shown in Figure 2 . The average values for the variables are:

$$a = 0.0006611 \pm 0.0000019 \frac{m^3}{\text{mol}}$$
$$b = 0.9999999 \pm 0.0000004.$$

According to the Loretz-Lorenz law, this results in the following refractive index in a normal atmosphere with T = 15 °C and p = 1013 hPa:

$$n = 1.0002795 \pm 0.0000009 \tag{3}$$

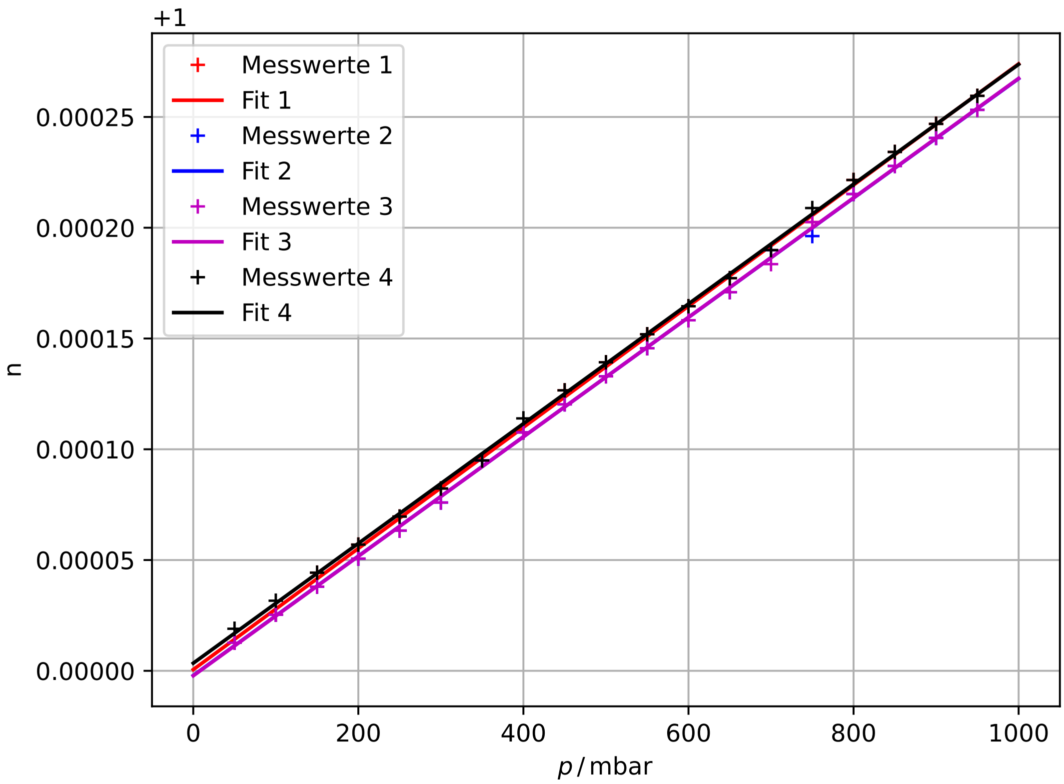

Abbildung 2: The calculated refractive indices n for air and the fit.

4 Diskussion

The measured values and the results obtained are in line with the expectations. An overview of the determined and theoretical values, as well as the respective deviation, can be found in table Tabelle 5. The determined contrasts follow the expected distribution and no major deviations are recognizable. As expected, the extremes can also be found at multiples of 45°.

For the refractive index of glass, $n_{\text{glass}} = 1.64 \pm 0.13$ was determined. The theoretical value is $n_{\text{glass, theo}} = 1.45$ [1]. The determined value therefore has a deviation of 13,10 %. One reason for this slightly higher deviation may lie in the way the experiment was carried out. Here, the intensity maxima and minima were only recorded with one diode instead of two.

The theoretical value for air is $n_{\text{air, theo}} = 1.000292$ [1]. Averaged over all measurement series, the refractive index of air in a standard atmosphere is $n_{\text{air}} = 1.0002795 \pm 0.0000009$, which represents a deviation of $\ll 1\%$ from the theoretical value.

Tabelle 5: The refractive indices determined for glass and air compared to the respective theoretical values.

	n_{Glas}	n_{Luft}
Theorie	1,45	1,000292
Versuch	1.64 ±0.13	1.0002795 ±0.0000009
Abweichung	13.10 %	0.0012 %

Literatur

[1] chemie.de. *Brechzahl.* URL: `http://www.chemie.de/lexikon/Brechzahl.html` (besucht am 13. 04. 2022).