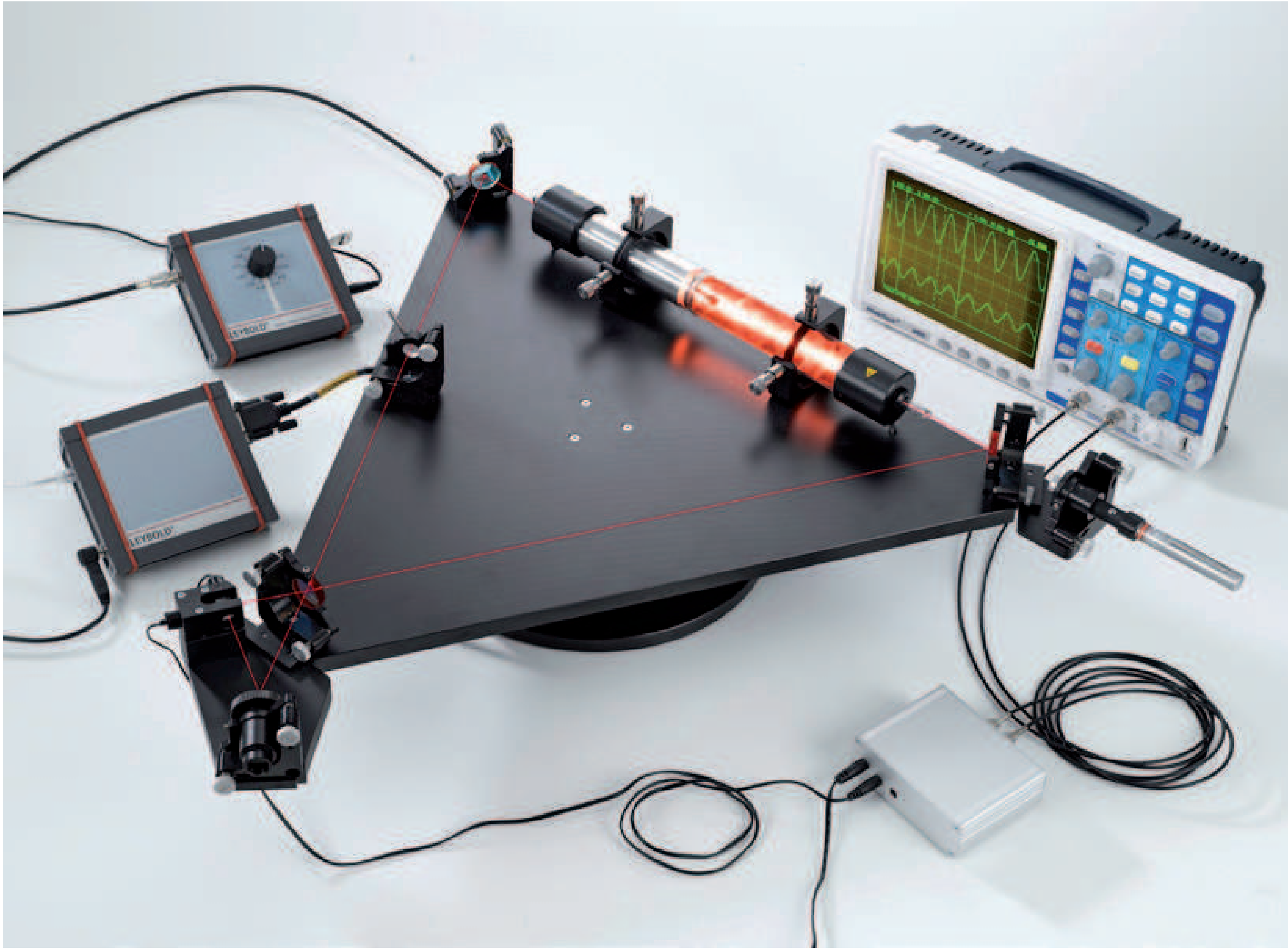
LEYBOLD®

PHOTONICS EXPERIMENTS



PHOTONICS

■ PHOTONICS

SD S.A.R.L. SYSTEMES DIDACTIQUES

LD DIDACTIC

PHOTONICS EXPERIMENTS

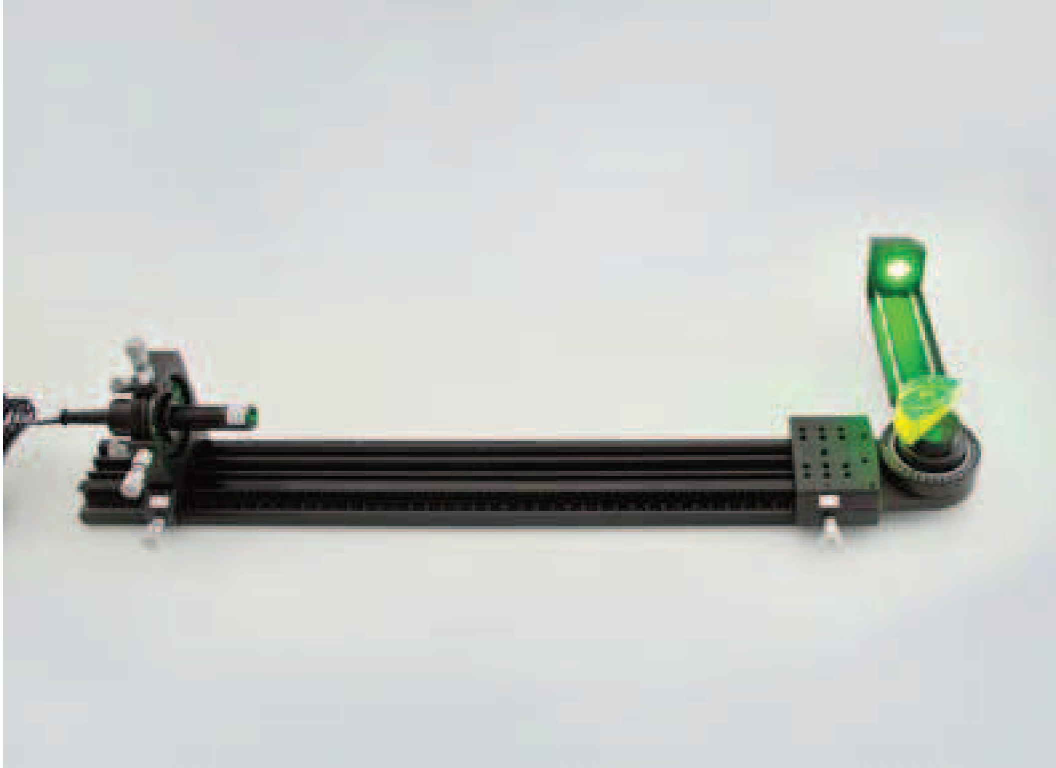
LEYBOLD®

P5.8.2

BASIC OPTICS

P5.8.2.1
Absorption and emission

P5.8.2.2
Refraction of light



Refraction of light (P5.8.2.2)

Cat. No.	Description	P5.8.2.1	P5.8.2.2
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	
474 5217	Plano-Convex Lens f = 60 mm, C25 Mount	2	
474 161	Absorption Unit	1	
474 5224	Phosphorescing Disc, C25 mount	1	
474 5261	Fluorescent Filters, Set of 3	1	
474 5302	Tranmission Grating, 600 lines/mm	1	
474 107	Filter Plate Holder	2	
474 5457	Screen with rider	1	
474 306	Photodetector signal conditioning box	1	
474 108	SiPIN photodetector	1	
531 173	Digital multimeter DMM 121	1	
575 24	Screened cable, BNC/4 mm	1	
474 301	Adaptive Power Supply	1	
474 5411	LED Lamp, White	1	
474 5412	LED Lamp, Red	1	
474 5415	LED Lamp, Blue	1	
474 5442	Profile rail, 500 mm	1	1
474 209	Mounting Plate C25 with Carrier 20 mm	3	
474 2112	Adjustment holder, 4 axes, with stop ang	1	1
474 251	Transport and Storage Box #01	1	1
474 7201	Manual Emission and Absorption	1	
474 133	Optical Fibre Model		1
474 204	Collection of Mounted Models		1
474 5453	Crossed Hair Target in C25 mount		1
474 5418	Diode Laser Module, 532 nm		1
474 121	Swivel Unit with Carrier		1

Cat. No.	Description	P5.8.2.1	P5.8.2.2
474 6411	Mounting plate 40, C25		1
474 7202	Manual Brechung des Lichtes		1

The laws which are related to absorption and emission are discussed and investigated in the experiment P5.8.2.1. With an absorbing sample the Lambert-Beer law is verified by measuring the transmitted light with a photodiode. Light sources of different colours are used to excite fluorescent samples. The absorption and emission of light is visualized spectrally using an optical grating.

Within the frame of the experiment P5.8.2.2 the Snellius Law is verified quantitatively. Deflection, offset and guidance of light travelling in and through transparent materials are demonstrated. The propagation of light through an optical fibre is simulated by a wave guide model. A model for diffraction of light rays on a rain drop is also given to understand the origin of rainbows.

Reflection and transmission (P5.8.2.7)

P5.8.2

BASIC OPTICS

P5.8.2.6
Polarisation of light

P5.8.2.7
Reflection and transmission

Cat. No.	Description	P5.8.2.6	P5.8.2.7
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	1
474 5260	Optical Quartz Plate in C25 Mount	1	
474 5320	Quarter wave plate, C25	1	
474 5275	Half Wave Plate, C25 Mount	1	
474 1124	Polariser / Analyser with Rotator	2	2
474 306	Photodetector signal conditioning box	1	
474 321	Si PIN Photodetector	1	
531 173	Digital multimeter DMM 121	1	1
575 24	Screened cable, BNC/4 mm	1	1
474 301	Adaptive Power Supply	1	1
474 5411	LED Lamp, White	1	1
474 5412	LED Lamp, Red	1	
474 5418	Diode Laser Module, 532 nm	1	1
474 5442	Profile rail, 500 mm	1	1
474 209	Mounting Plate C25 with Carrier 20 mm	2	1
474 2112	Adjustment holder, 4 axes, with stop ang	1	1
474 251	Transport and Storage Box #01	1	1
474 7206	Manual Polarisation of light	1	
474 6413	Collimation optics in mounting plate 40		1
474 6431	Polarisation analyser 40 mm, VIS		1
474 5453	Crossed Hair Target in C25 mount		1
474 5270	Glass Plate on Rotary Disc		1
474 5271	Dichroic Mirror on Rotary Disc		1
474 5272	Front Face Mirror on Rotary Disc		1
474 5302	Tranmission Grating, 600 lines/mm		1
474 6414	Photodetector for Pivot Arm		1
501 10	BNC adapter, straight		1
474 121	Swivel Unit with Carrier		1
474 238	Carrier for rotatable insert		1
474 7207	Manual Reflection and Transmission		1

Experiment P5.8.2.6 deals with the observation of polarisation of light. The law of Malus is verified and the optical activity of optical crystals are demonstrated. As application of double refractive optics the quarter and halve wave plates are subject of measurements and demonstration. As light sources a green laser and a LED are used.

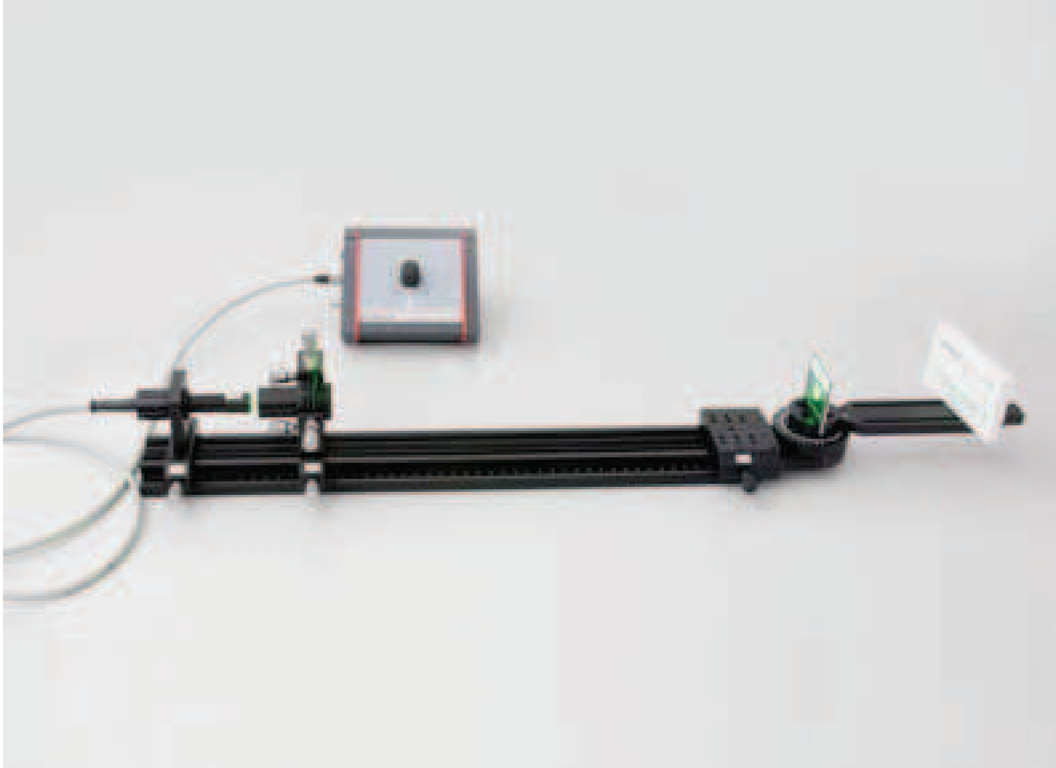
Although the Fresnel Laws are still valid, nowadays mirrors can be produced which seem to bypass these laws. By dielectric coating such mirrors are made either to optimize or to suppress reflection. The functionality of those coatings is based on interference which allows for instance nearly 100 % reflectivity of mirrors (e.g. for laser cavities) or anti-reflecting windows. First the experiment P5.8.2.7 demonstrates the reflection law which is verified on a metal coated mirror. The second part deals with the quantitative verification of the Fresnel Laws on a specially shaped plate and with polarized light. At last the spectral performance of dielectrically coated mirrors is investigated by means of a white light source.

P5.8.2

BASIC OPTICS

P5.8.2.8
Diffraction of light

P5.8.2.9
Interference of light



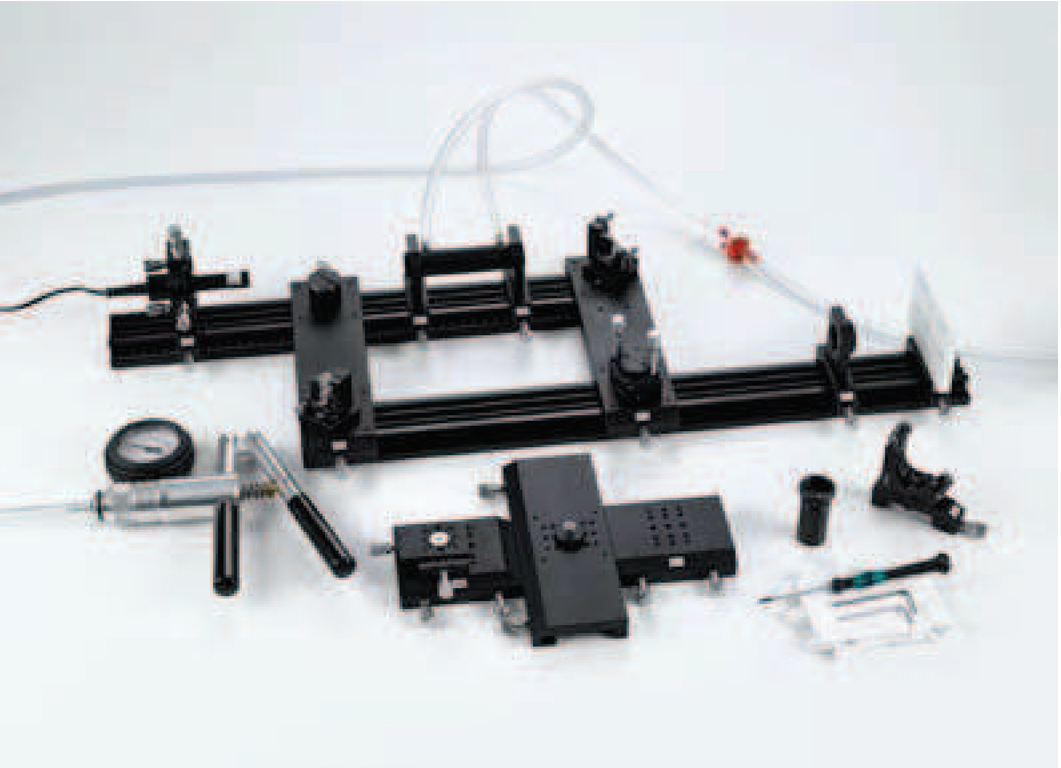
Diffraction of light (P5.8.2.8)

Cat. No.	Description	P5.8.2.8	P5.8.2.9
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	1
474 5263	Beam expander 6x	1	1
474 5298	Circular apertures	1	
474 5299	Gauze 300 mesh	1	
474 5300	Single Slit 0.06 mm	1	
474 5301	Double slit	1	
474 6417	Optical Screen with XY Scale	1	
474 6414	Photodetector for Pivot Arm	1	
531 183	Digital multimeter 3340	1	
575 24	Screened cable, BNC/4 mm	1	
501 10	BNC adapter, straight	1	
474 301	Adaptive Power Supply	1	1
474 5411	LED Lamp, White	1	1
474 5418	Diode Laser Module, 532 nm	1	1
474 5442	Profile rail, 500 mm	1	1
474 121	Swivel Unit with Carrier	1	
474 209	Mounting Plate C25 with Carrier 20 mm	1	4
474 2112	Adjustment holder, 4 axes, with stop ang	1	1
474 251	Transport and Storage Box #01	1	1
474 7208	Manual Diffraction of light	1	
474 5221	Biconcave lens f = -20 mm, C25 mount		1
474 5251	Fresnel Zone Plate, C25 mount		1
474 5252	Fabry Perot Insert, C25 mount		1
474 5277	Newton's Rings Optics		1

Cat. No.	Description	P5.8.2.8	P5.8.2.9
474 176	Fresnel Mirror Assembly		1
474 5457	Screen with rider		1
474 213	Adjustment Holder 1 inch, left		1
474 7209	Manual Interference of light		1

In the experiment P5.8.2.8 Fresnel and Fraunhofer types of diffraction are discussed. Investigations are performed using monochromatic laser light which will be diffracted on slits and holes of various widths and gratings. Thin wires show impressively the Babinet theorem stating that complementary masks result in the same diffraction pattern. The obtained diffraction patterns will be observed on a target screen and can be measured by a photodiode quantitatively.

Different examples of interference phenomenon are discussed and demonstrated in the experiment P5.8.2.9. Fresnel mirror, wedges and half-lenses are tools which "divide" one light source into two and superimpose their coherent portions. On a set-up proposed by Newton, interference caused by thin layers can be determined quantitatively. Since diffraction usually generates interference patterns, a Fresnel plate is used for illustrating this effect. Finally, a model of a Fabry Perot resonator demonstrates the working principle of wavelength selection in a cavity.



Optical interferometer (P5.8.3.1)

P5.8.3

OPTICAL APPLICATIONS

P5.8.3.1
Optical interferometer

P5.8.3.2
Refractometer

Cat. No.	Description	P5.8.3.1	P5.8.3.2
474 5220	Biconcave Lens f = -10 mm, C25 mount	1	
474 5264	Beam expander 2.7x	1	
474 169	Gas Cuvette Assembly	1	
474 171	Mach Zehnder Beam Combining Assembly	1	
474 174	Mach-Zehnder Beam Splitting Assembly	1	
474 5457	Screen with rider	1	1
474 5418	Diode Laser Module, 532 nm	1	
474 5441	Profile Rail, 300 mm	2	
474 5442	Profile rail, 500 mm	1	1
474 5449	Angle Joint, Cross Piece	1	
474 209	Mounting Plate C25 with Carrier 20 mm	3	1
474 2112	Adjustment holder, 4 axes, with stop ang	1	1
474 251	Transport and Storage Box #01	2	1
474 7210	Manual Optical Interferometer	1	
474 5225	Polariser, C25 mount		1
474 404	Prism assembly		1
474 405	Beam Bending Assembly 22.5 °deg;- 45°, left		1
474 406	Beam Bending Assembly 22.5 °deg;- 45°, right		1
474 5307	Set of Test Liquids		1
474 301	Adaptive Power Supply		1
474 5413	LED amber in C25 housing		1
474 7211	Manual Refractometer		1

While the Michelson interferometer is mainly used to determine the movement of a reflecting object in a nm scale, the Mach-Zehnder interferometer investigates transparent objects and is particularly useful for studying liquid or gas dynamics. Since the Mach-Zehnder is a unidirectional interferometer it is especially useful for measurements where the samples have to be traversed only once or in one direction. Within the frame of the experiment P5.8.3.1 both, a Michelson- and a Mach-Zehnder interferometer will be realized. The former demonstrates the principle generation of interference patterns and the use of fringe counting in metrology. The latter uses the interference pattern to visualize changes of the index of refraction as a result of changes in physical properties of gasses, like pressure or composition.

The refractometer is an essential instrument for empirical identification of pure substances, purity measurements, and quantitative analysis of solutions. It is used in the food and beverage industry as well as in the chemical and pharmaceutical industry for quality control and check-ups on compound identities. The experiments in P5.8.3.2 are performed on a model of an Abbé refractometer to show the implementation on modern, computer driven standard refractometers. This refractometer measures refraction of liquids, solutions and solid materials by observing the shadow line of the light beam on a screen.

P5.8.3

OPTICAL APPLICATIONS

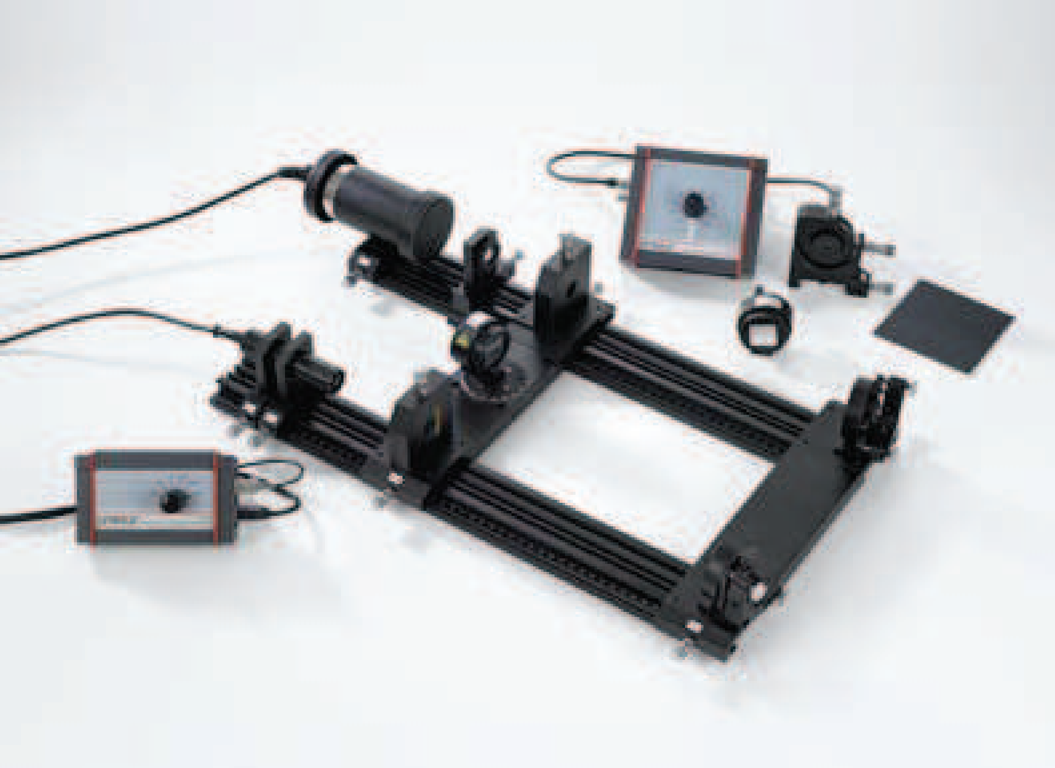
P5.8.3.3
Holography

Holography (P5.8.3.3)

Cat. No.	Description	P5.8.3.3
474 5219	Biconcave Lens f = -5 mm, C25 mount	2
474 5220	Biconcave Lens f = -10 mm, C25 mount	2
474 6418	Model for Holography	1
474 6419	Set of Tools for Holography	1
474 5303	Photographic plate, 532 nm, 63 x 63 mm	30
474 164	Set of Development Equipment	1
474 167	Holography Combining Assembly	1
474 168	Holography Beam Splitting Assembly	1
474 3024	Digital Laser Controller and Timer	1
474 5419	Diode Laser Module, 532 nm with Window	1
474 5442	Profile rail, 500 mm	2
474 209	Mounting Plate C25 with Carrier 20 mm	1
474 211	Adjustment holder, 4 axes, carrier 20 mm	1
474 165	Set of Holography Chemicals	1
675 3400	Water, pure, 1 l	1
671 0010	Pyrocatechol, 100 g	1
675 3270	Vitamin C, 50 g	1
673 7800	Sodium sulfite, 100 g	1
672 1700	Urea, 100 g	1
673 5600	Natrium carbonate, anhydrous, 100 g	1
474 251	Transport and Storage Box #01	1
474 7212	Manual Holography	1
474 5253	Photodetector, mini Si PIN, connection lead	1*
531 183	Digital multimeter 3340	1*
575 24	Screened cable, BNC/4 mm	1*
501 10	BNC adapter, straight	1*

* additionally recommended

In the experiment P5.8.3.3 both types, transmission and reflection holograms can be recorded. In a first set-up the stability of the working place and environment is tested by an interferometer. It is extremely important for making holograms that the set-up has to be stable within the range of the optical wavelengths. The recording techniques of transmission and reflection holography will be discussed and experimentally investigated. Finally the development of the holographic plates will be performed.



Spectral analysis (P5.8.3.5)

P5.8.3

OPTICAL APPLICATIONS

P5.8.3.4
Diffraction gratings

P5.8.3.5
Spectral analysis

P5.8.3.7
LED and laser diode

Cat. No.	Description	P5.8.3.4	P5.8.3.5	P5.8.3.7
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	1	1
474 5256	Biconvex lens f = 60 mm, C25 Mount	1		
474 5263	Beam expander 6x	1		
474 5264	Beam expander 2.7x	1		
474 5268	Transmission gratings, Set of 5	1		
474 6417	Optical Screen with XY Scale	1		1
474 306	Photodetector signal conditioning box	1	1	
474 321	Si PIN Photodetector	1		
531 173	Digital multimeter DMM 121	1	1	1
575 24	Screened cable, BNC/4 mm	1	1	1
474 5417	Spectral Lamp with Slit and Power Supply	1	1	
474 5418	Diode Laser Module, 532 nm	1		
474 5442	Profile rail, 500 mm	1	2	1
474 121	Swivel Unit with Carrier	1		1
474 6411	Mounting plate 40, C25	2		
474 209	Mounting Plate C25 with Carrier 20 mm	1	2	2
474 2112	Adjustment holder, 4 axes, with stop ang	1	1	
474 251	Transport and Storage Box #01	1	2	1
474 7213	Manual Diffraction gratings	1		
474 5218	Biconvex Lens f = 20 mm, C25-T Mount		1	
474 5211	Acrylic Absorption Filter		1	
474 177	Spectrometer Mirror Assembly		1	
474 178	Spectrometer Grating Assembly		1	
474 107	Filter Plate Holder		1	
474 108	SiPIN photodetector		1	
474 301	Adaptive Power Supply		1	1
474 5411	LED Lamp, White		1	1
474 7214	Manual Spectral analysis		1	
474 5222	Cylindrical Lens f = 25 mm, C25 Mount			1

Cat. No.	Description	P5.8.3.4	P5.8.3.5	P5.8.3.7
474 5223	Cylindrical Lens f=80 mm, C25 Mount			1
474 6431	Polarisation analyser 40 mm, VIS			1
474 5302	Tranmission Grating, 600 lines/mm			1
474 6414	Photodetector for Pivot Arm			1
501 10	BNC adapter, straight			1
474 5412	LED Lamp, Red			1
474 5415	LED Lamp, Blue			1
474 5420	Dimo diode laser module, 630 nm (red)			1
474 2114	Adjustment holder, 4 axes, rotary insert			1
474 213	Adjustment Holder 1 inch, left			1
474 7220	Manual LED and Laser Diode			1

In the experiment P5.8.3.4, transmission gratings of different grating constants are investigated. A light source with known wavelength is used to characterize a specific grating. Finally, a two-dimensional grating is not only used to produce impressive patterns of light spots, but gives an idea about the principles of x-ray diffraction on crystal lattices or atomic layers.

The experiment P5.8.3.5 builds a model for a standard grating monochromator as well as a spectrograph. With a white light lamp a source for a continuous spectrum is provided. Here the spectrometer is used as a spectrograph and grating diffraction of first and higher orders as well as absorption spectroscopy can be demonstrated. Using the set-up in the monochromator mode in combination with a spectral lamp, line spectra are detected and features like spectral resolution or line profile are measured.

For a comprehensive study of the properties of LED and laser diodes the setup of the experiment P5.8.3.7 comes with four different light sources. One diode laser having a wavelength of 630 nm and three high brightness LED emitting white, red and blue radiation. The respective light source is plugged into the four axes adjustment holder and connected to the adaptive power supply. One lens is used for the beam collimation and cylindrical lenses for transforming the elliptical beam of the laser diode into an almost circular one.

P5.8.4

OPTICAL IMAGING AND COLOUR

P5.8.4.1
Optical filter

P5.8.4.3
Camera and imaging

Optical filter (P5.8.4.1)

Cat. No.	Description	P5.8.4.1	P5.8.4.3
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	
474 5217	Plano-Convex Lens f = 60 mm, C25 Mount	1	
474 5289	Interference Filter 550 nm, in C25 Mount	1	
474 5262	Optical filters, Set of 8	1	
474 5302	Tranmission Grating, 600 lines/mm	1	
474 107	Filter Plate Holder	1	
474 6417	Optical Screen with XY Scale	1	
474 306	Photodetector signal conditioning box	1	
474 321	Si PIN Photodetector	1	
531 173	Digital multimeter DMM 121	1	
575 24	Screened cable, BNC/4 mm	1	
474 301	Adaptive Power Supply	1	1
474 5411	LED Lamp, White	1	
474 5416	LED Lamp NIR in C25 housing	1	1
474 5442	Profile rail, 500 mm	1	1
474 121	Swivel Unit with Carrier	1	
474 6411	Mounting plate 40, C25	1	
474 209	Mounting Plate C25 with Carrier 20 mm	2	1
474 2112	Adjustment holder, 4 axes, with stop ang	1	
474 213	Adjustment Holder 1 inch, left	1	
474 251	Transport and Storage Box #01	1	1
474 7216	Manual Optische Filter	1	
474 104	Focussing Optics, f = 60 mm		1
468 75	Filter, infrared barrier		1
474 281	CCD day and night camera module		1
474 9112	CCD Camera Control Software		1

Cat. No.	Description	P5.8.4.1	P5.8.4.3
524 004	Adapter, USB port/serial port		1
474 5467	Flat panel TV 19 inch		1
474 7218	Manual Camera		1
	additionally required: PC with Windows XP or higher		1

In the experiment P5.8.4.1 different kinds of filters are presented. With a set of colour filters transmission and absorption of certain spectral ranges are demonstrated. Neutral density filters are provided to dim the whole spectral range. An infrared LED and an IR filter demonstrate light filtering in the IR range.

In the experiment P5.8.4.3 a high performance industrial CCD zoom camera with computer interface is subject of a variety of investigations. The rapid development in the area of CCD sensors created a great variety of new possibilities. Most of them are introduced here and one get experienced in the manifold of parameters which needs to be set according to the requirements. The CCD camera used can be operated as day as well as night vision camera. In the latter case an IR blocking filter is switched out of the way between the objective and the CCD chip enabling the sensitivity in the near infra red region (NIR). The camera is fully controlled by a PC, the video output is connected to a TFT monitor.


Laser Doppler Anemometry with CASSY (P5.8.5.1)

P5.8.5
LASER BASICS

P5.8.5.1
Laser Doppler Anemometry with CASSY

Cat. No.	Description	P5.8.5.1
471 821	Head unit for 5 mW He-Ne laser	1
471 825	Power supply for 5 mW He-Ne-laser	1
470 010	Laser holder for 5 mW He-Ne laser	1
473 431	Holder for beam divider	1
473 432	Beam divider, 50 %	1
473 461	Planar mirror with fine adjustment	1
460 02	Lens in frame, f=50 mm	1
460 03	Lens in frame, f=100 mm	1
460 21	Holder for plug-in elements	1
460 22	Holder with spring clips	2
460 26	Iris diaphragm	1
461 63	Set of 4 different diaphragms	1
469 96	Diaphragm with 3 diffraction holes	1
441 53	Screen, translucent	1
460 335	Optical bench with standardised profile, 0.5 m	1
460 32	Optical bench with standardised profile, 1 m	1
460 374	Optics rider, 90/50	10
460 380	Cantilever arm	1
460 385	Extension rod	1
311 77	Steel tape measure, 2 m	1
524 013	Sensor-CASSY 2	1
524 220	CASSY Lab 2	1
558 835	Silicon photodetector	1
532 20	AC/DC amplifier 30 W	1
577 68	Resistor, 100 kΩ, STE 2/19	1
575 24	Screened cable, BNC/4 mm	1
501 641	Two-way adapters, red, set of 6	1
590 02ET2	Clip plugs, small, set of 2	1
683 70	Reflecting particles, 10 g	1
664 146	Reaction tube	1
602 404	Separation Funnel, 500 ml	1
604 433	Silicone tubing, 7 mm diam., 1 m	2
667 175	Hofmann tubing clamp, 20 mm	1
604 5672	Double microspatula, steel, 150 mm	1
602 010	Beaker, Boro 3.3, 150 ml, tall	1
604 215	Measuring beaker, clear SAN 500 ml	1
300 01	Stand base, V-shaped, large	1
300 44	Stand rod, 100 cm, 12 mm diam.	1
666 546	Stand ring with clamp, 100 mm diam.	1
500 401	Connecting lead, 19 A, 10 cm, red	1
501 45	Connecting lead, 19 A, 50 cm, red/blue, pair	1
471 828	Adjustment goggles for He-Ne-laser	1*
	additionally required: PC with Windows XP/Vista/7/8/10 (x86 or x64)	1

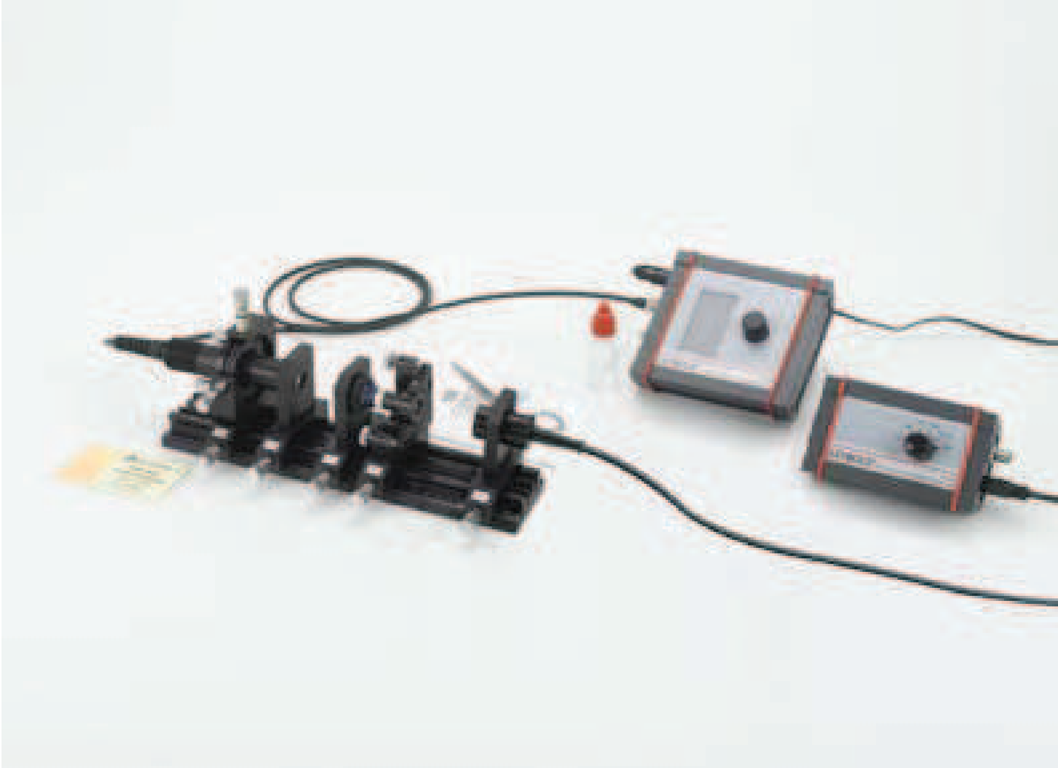
* additionally recommended

Laser Doppler anemometry is a non-contact optical measurement method to obtain the velocity of a flow (fluid, gas). In the experiment P5.8.5.1 a laser Doppler anemometer is assembled. Measurements of the flow velocity of a fluid in a tube are conducted by measuring the velocity of small particles carried along in the flow. Moving through the measuring volume the particles scatter light of a laser. The scattered light is frequency shifted due to the Doppler effect. The frequency shift is determined and converted into the particle velocity, *i.e.* the flow velocity.

P5.8.5
LASER BASICS

P5.8.5.2
Laser safety

P5.8.5.3
Emission & absorption / Optical pumping



Emission & absorption / Optical pumping (P5.8.5.3)

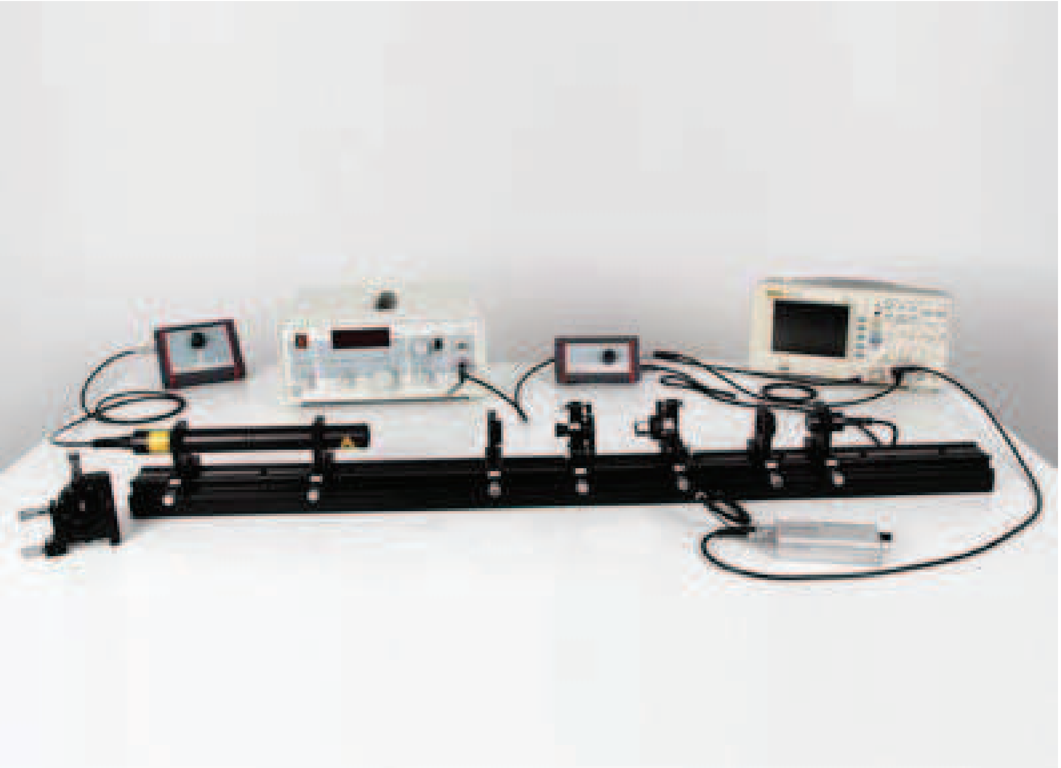
Cat. No.	Description	P5.8.5.2	P5.8.5.3
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	
474 5220	Biconcave Lens f = -10 mm, C25 mount	1	
474 217	Scatter Probe with Holder	1	
468 77	Light filter, green	1	
474 107	Filter Plate Holder	1	1
474 306	Photodetector signal conditioning box	1	1
474 321	Si PIN Photodetector	1	
531 173	Digital multimeter DMM 121	1	
575 24	Screened cable, BNC/4 mm	1	1
474 5464	Oscilloscope, Dual Channel, Digital	1	1*
501 06	HF-Cable, BNC-BNC, 1.5 m	1	1*
474 5460	Laser Power Meter	1	
474 5462	Laser Power Sensor, 1 nW ... 50 mW	1	
474 5463	Laser Energy Sensor, 300 nJ ... 600 µJ	1	
474 309	Controller for Pulsed Laser Diode	1	
474 5428	Pulsed Diode Laser Module 908 nm	1	
474 5418	Diode Laser Module, 532 nm	1	
474 5442	Profile rail, 500 mm	1	1
474 121	Swivel Unit with Carrier	1	
474 6411	Mounting plate 40, C25	2	
474 209	Mounting Plate C25 with Carrier 20 mm	1	
474 211	Adjustment holder, 4 axes, carrier 20 mm	1	
474 2112	Adjustment holder, 4 axes, with stop ang	1	
474 122	Optics cleaning set	1	1
671 9700	Ethanol, absolute, 250 ml	1	1
474 251	Transport and Storage Box #01	2	1
474 7101	LIT: Laser Safety	1	
474 1031	Module B - Collimating optics on carrier MG-65 with Melles Griot		1
474 104	Focussing Optics, f = 60 mm		1

Cat. No.	Description	P5.8.5.2	P5.8.5.3
474 5310	Crystal in holder Nd:YAG 1064 nm		1
474 113	Laser Mirror Adjustment Holder, left		1
474 137	Spatial filter with adjustable iris		1
474 5453	Crossed Hair Target in C25 mount		1
468 74	Filter, infrared		1
474 4025	IR converter screen 0.8 - 1.6 µm		1
474 108	SiPIN photodetector		1
531 183	Digital multimeter 3340		1
474 302	Controller for Diode Laser		1
474 1021	Single Mode Diode Laser Head with Adjust		1
474 7102	LIT: Emission & Absorption/Opt. Pumping		1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m		1*

* additionally recommended

Laser can emit dangerous radiation. To protect against any injury international safety rules like IEC 60825 or ANSI Z136 were defined. The lasers are classified into different classes with the individual maximum permissible exposure limit (MPE) which is defined as intensity, power per square centimetre (W/cm^2). To classify a laser one needs to know its intensity in order to compare it with the MPE values. For pulsed laser its energy is used instead of the power of continuous wave (cw) laser. Within the experiment P5.8.5.2 one pulsed and one cw laser is classified. For this purpose the intensity needs to be determined. To calculate this value the power and the beam diameter are measured. For the pulsed laser its repetition rate and the emitted energy is measured.

The experiment P5.8.5.3 introduces to optical pumping as well as emission and absorption. Due to the pumping process spontaneous and stimulated emission is generated. The emission is temporarily as well spectroscopical measured and analyzed. The tuning of the emission wavelength of the pump diode laser due to the temperature allows the recording of the absorption spectrum. From the timely decay of the fluorescence light the lifetime of the excited state is measured and the Einstein coefficient for stimulated emission calculated.



Fabry Perot spectrum analyser, basic (P5.8.5.4_b)

P5.8.5

LASER BASICS

P5.8.5.4
Fabry Perot spectrum analyser

Cat. No.	Description	P5.8.5.4 (b)
474 104	Focussing Optics, f = 60 mm	1
474 5236	Laser Mirror, R = 100 mm, M16 Mount	1
474 5239	Laser Mirror, R = 100 mm, M12 Mount	1
474 113	Laser Mirror Adjustment Holder, left	1
474 317	Piezo Actuator Controller	1
474 139	Piezo Element with Adjustment Holder	1
522 561	Function generator P	1
501 02	BNC cable, 1 m	2
501 091	BNC T adapter	1
575 24	Screened cable, BNC/4 mm	1
474 306	Photodetector signal conditioning box	1
474 108	SiPIN photodetector	1
474 5464	Oscilloscope, Dual Channel, Digital	1
474 303	HeNe Laser High Voltage supply, adjustable	1
474 5421	HeNe Pilot Laser Ø 30 mm	1
474 5445	Profile Rail, 1000 m	1
474 210	Mounting plate Ø 30 mm, carrier 20 mm	2
474 122	Optics cleaning set	1
671 9700	Ethanol, absolute, 250 ml	1
474 251	Transport and Storage Box #01	2
474 7103	Manual Fabry Perot Resonator	1
474 1404	Lens f = 150 mm, C25 Mount and Plate	1*
474 140	Beam expander lens, adjustment holder	1*
474 5213	Achromat f = 20 mm, C25 Mount	1*
474 5234	Laser Mirror, flat, M16 mount	1*

Cat. No.	Description	P5.8.5.4 (b)
474 5235	Laser Mirror, R = 75 mm, M16 Mount	1*
474 5237	Laser Mirror, flat, M12 Mount	1*
474 5238	Laser Mirror, R = 75 mm, M12 Mount	1*

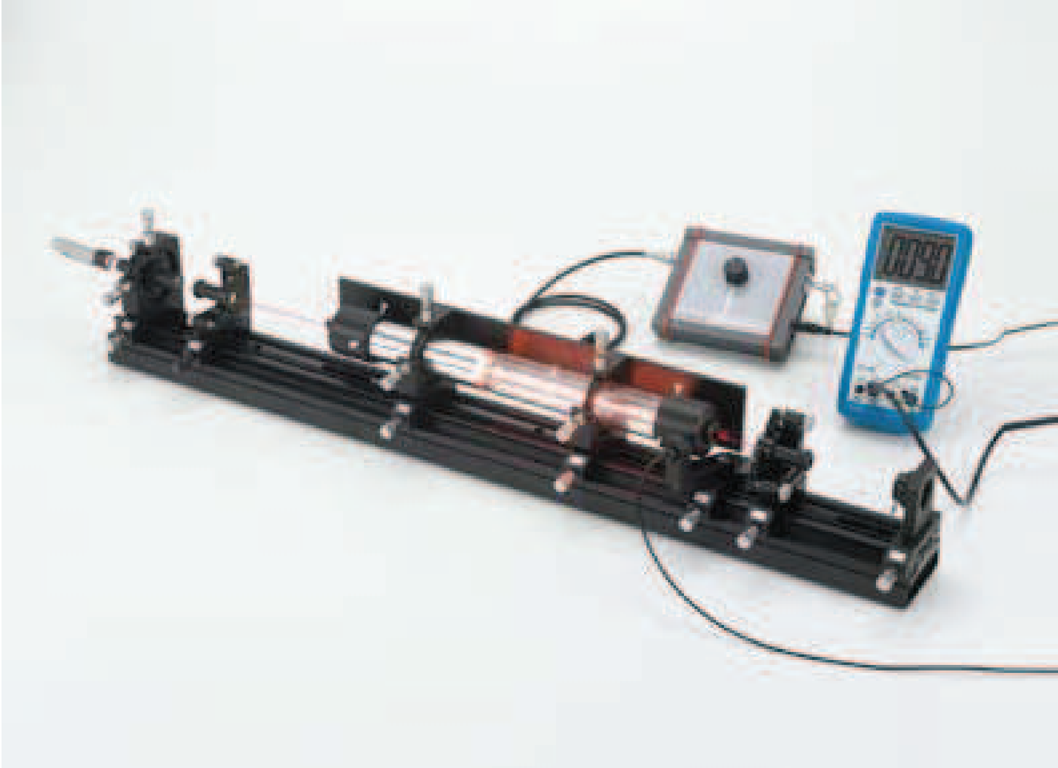
* additionally recommended

A Fabry Perot resonator is formed by two mirrors aligned parallel to each other. The resulting cavity changes transparency when the distance of the mirrors is changed by a multiple of half the wavelength. Scanning the length of the cavity creates a high resolution spectrometer. Experiment P5.8.5.4 shows an open frame scanning Fabry Perot. As scanner a Piezo element and as probe a two mode Helium Neon laser is used. The mode spectrum of the Helium Neon laser is displayed on an oscilloscope and the characteristic parameter like finesse, free spectral range, resolution and contrast are measured and discussed. Additional components for beam expansion are used to investigate the effect of technical Finesse. Additional mirrors are used to show the difference of a plane and confocal Fabry Perot arrangement.

P5.8.5
LASER BASICS

P5.8.5.5
Helium Neon laser

P5.8.5.6
Laser frequency stabilisation



Helium Neon laser, basics (P5.8.5.5_b)

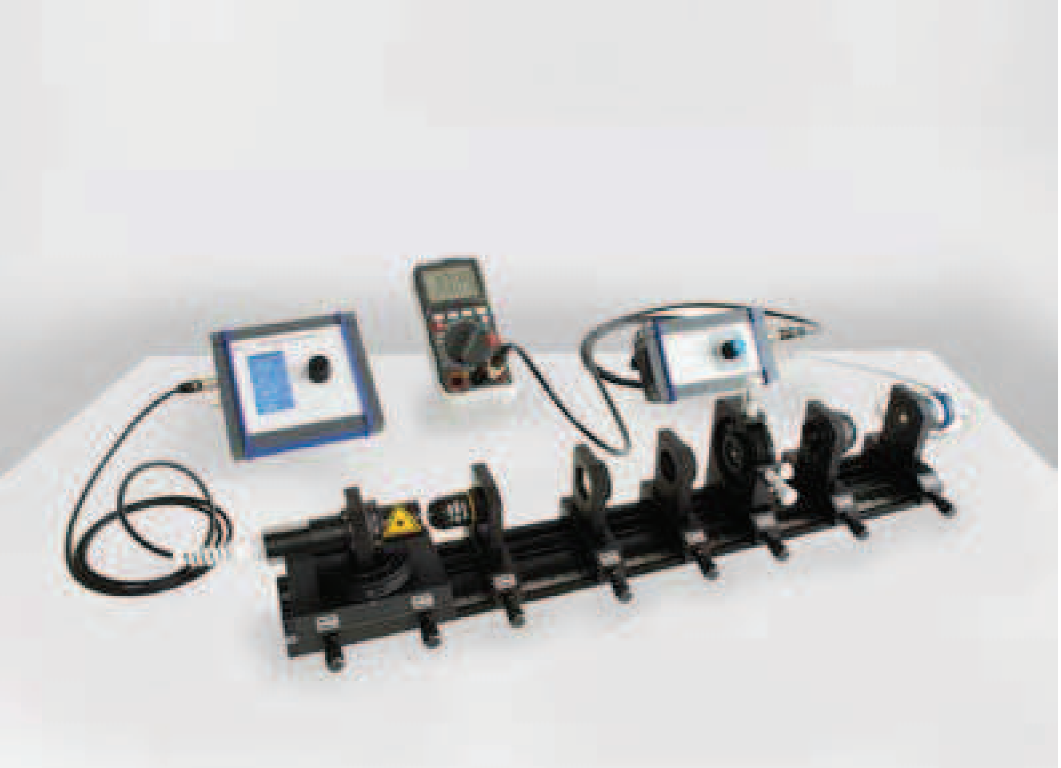
Cat. No.	Description	P5.8.5.5 (b)	P5.8.5.6
474 5243	Laser Mirror VIS 700, M16 Mount	1	
474 5246	Laser Mirror, flat, M16 Mount	1	
474 113	Laser Mirror Adjustment Holder, left	1	
474 114	Laser Mirror Adjustment Holder, right	1	
474 137	Spatial filter with adjustable iris	1	
474 1082	Module G (SiPIN) photodetector on swivel arm	1	
531 183	Digital multimeter 3340	1	
575 24	Screened cable, BNC/4 mm	1	
501 10	BNC adapter, straight	1	
474 303	HeNe Laser High Voltage supply, adjustable	1	1
474 127	Main Laser Tube with XY-Adjustment	1	
474 5422	Pilot laser 532 nm (green)	1	
474 5445	Profile Rail, 1000 m	1	
474 122	Optics cleaning set	1	
671 9700	Ethanol, absolute, 250 ml	1	
474 251	Transport and Storage Box #01	2	1
474 7104	Manual HeNe Laser	1	
474 5242	Laser Mirror OC 632, flat, M16 Mount	1*	
474 5244	Laser Mirror VIS 1000, M16 Mount	1*	
474 5245	Laser Mirror IR 713, M16 Mount	2*	
474 4025	IR converter screen 0.8 - 1.6 µm	1*	
474 126	Littrow prism with adjustment holder	1*	
474 141	Single Mode Etalon, Adjustmend Holder	1*	
474 142	Birefringent tuner	1*	
474 409	Mode separator and photodiode		1
474 112	Polarisation Analyzer		1

Cat. No.	Description	P5.8.5.5 (b)	P5.8.5.6
474 306	Photodetector signal conditioning box		1
474 108	SiPIN photodetector		1
474 5464	Oscilloscope, Dual Channel, Digital		1
501 06	HF-Cable, BNC-BNC, 1.5 m		1
474 312	Laser frequency stabilizer LSF-01		1
474 410	Two mode HeNe-laser		1
474 5442	Profile rail, 500 mm		1
474 7111	Manual Laser frequency stabilisation		1
	additionally required: PC with Windows XP or higher		1

* additionally recommended

The experiment P5.8.5.5 realises a Helium Neon laser from basic parts. The open frame cavity allows the variation of parameters to measure the beam profile for different cavity mirror configurations and distances. The laser tube is equipped with a Brewster's window on both sides allowing the study of polarisation and losses. Optionally, a Littrow prism selects other wavelengths than the main laser line at 632 nm, especially the orange line at 611 nm. Further line tuning is demonstrated by means of the optional birefringent tuner. 4 different lines can be demonstrated by this element. An etalon is used to obtain the single mode operation of the Helium Neon laser.

Stabilizing a gas laser emission against thermal change of the resonator is demonstrated in Experiment P5.8.5.6. Two longitudinal modes of a short Helium Neon laser are analysed and centered to the laser transition gain profile, thereby stabilizing the wavelength of emission. A PI controller with variable coefficients is used for the stabilisation.



Diode laser (P5.8.6.1)

P5.8.6
SOLID STATE LASER

P5.8.6.1
Diode laser

Cat. No.	Description	P5.8.6.1
474 5266	Collimating cylindrical lens f = 20 mm	1
474 5267	Collimating cylindrical lens f = 80 mm	1
474 1031	Module B - Collimating optics on carrier MG-65 with Melles Griot	1
474 5310	Crystal in holder Nd:YAG 1064 nm	1
474 113	Laser Mirror Adjustment Holder, left	1
474 112	Polarisation Analyzer	1
474 5453	Crossed Hair Target in C25 mount	1
474 4025	IR converter screen 0.8 - 1.6 µm	1
474 306	Photodetector signal conditioning box	1
474 108	SiPIN photodetector	1
531 183	Digital multimeter 3340	1
575 24	Screened cable, BNC/4 mm	1
474 302	Controller for Diode Laser	1
474 1012	Diode Laser Head, Dual Axes Rotary Mount	1
474 5442	Profile rail, 500 mm	1
474 209	Mounting Plate C25 with Carrier 20 mm	2
474 122	Optics cleaning set	1
671 9700	Ethanol, absolute, 250 ml	1
474 251	Transport and Storage Box #01	1
474 7105	Manual Diode Laser	1
474 5464	Oscilloscope, Dual Channel, Digital	1*
501 06	HF-Cable, BNC-BNC, 1.5 m	1*
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	1*

* additionally recommended

The goal of the experiment P5.8.6.1 is the study of the properties of a laser diode, i.e. the characteristic parameters like the output power and wavelength as function of the temperature. In a next step the spatial intensity distribution is measured. The more or less elliptical beam is formed by means of two cylindrical lenses into an almost circular beam.

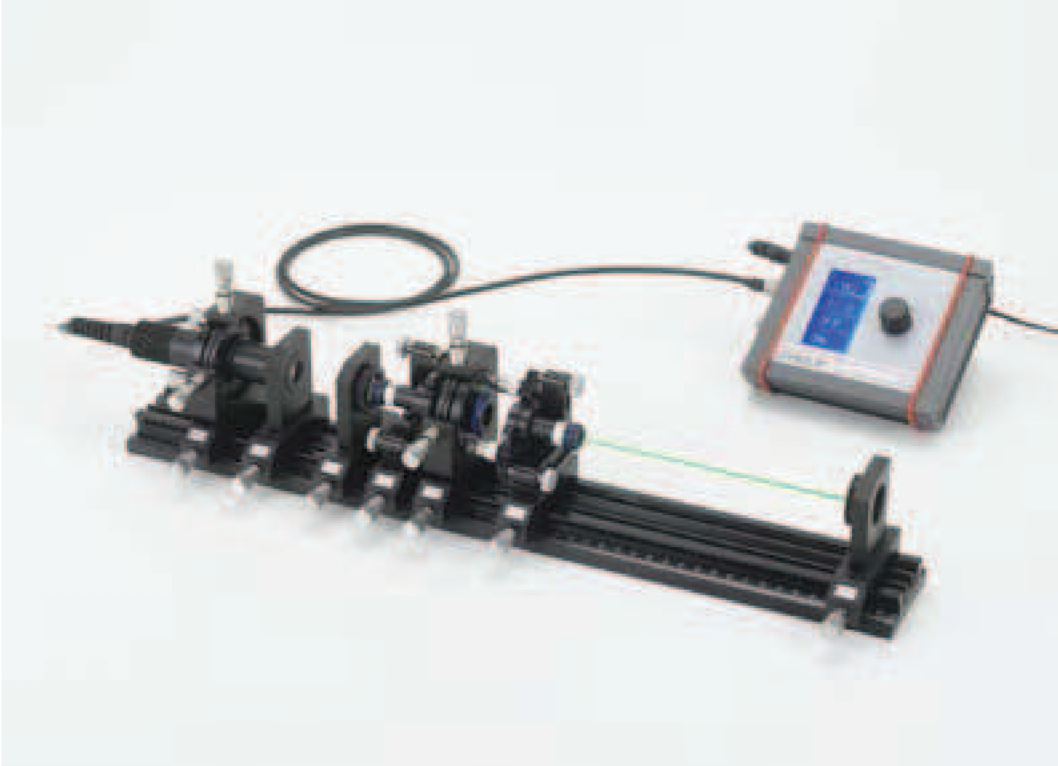
P5.8.6
SOLID STATE LASER

P5.8.6.2
Diode laser pumped Nd:YAG laser

P5.8.6.3
Frequency doubling,
1064 nm -> 532 nm

P5.8.6.4
Frequency doubling,
1320 nm -> 660 nm

P5.8.6.5
Q-switch operation



Frequency doubling, 1064 nm -> 532 nm (P5.8.6.3)

Cat. No.	Description	P5.8.6.2	P5.8.6.3	P5.8.6.4	P5.8.6.5
474 1031	Module B - Collimating optics on carrier MG-65 with Melles Griot	1	1	1	1
474 104	Focussing Optics, f = 60 mm	1	1	1	1
474 5310	Crystal in holder Nd:YAG 1064 nm	1	1		1
474 5311	Laser mirror in holder SHG 100	1	1		1
474 113	Laser Mirror Adjustment Holder, left	1	1	1	1
474 114	Laser Mirror Adjustment Holder, right	1	1	1	1
474 5453	Crossed Hair Target in C25 mount	1	1	1	1
474 107	Filter Plate Holder	1	1	1	1
468 74	Filter, infrared	1	1	1	1
474 4025	IR converter screen 0.8 - 1.6 µm	1	1	1	1
474 306	Photodetector signal conditioning box	1	1	1	1
474 108	SiPIN photodetector	1	1		1
474 5464	Oscilloscope, Dual Channel, Digital	1	1	1	1
501 06	HF-Cable, BNC-BNC, 1.5 m	1	1	1	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	1	1	1	1
474 302	Controller for Diode Laser	1	1	1	1
474 102	Diode Laser Head with Adjustment Holder	1	1	1	1
474 5442	Profile rail, 500 mm	1	1	1	1
474 122	Optics cleaning set	1	1	1	1
671 9700	Ethanol, absolute, 250 ml	1	1	1	1
474 251	Transport and Storage Box #01	1	1	1	1
474 7106	Manual DPSSL	1	1	1	1
474 109	KTP Crystal with Adjustment Holder		1		
468 77	Light filter, green		1		
474 137	Spatial filter with adjustable iris		1*	1*	
474 1094	Red SHG Crystal in holder			1	
474 5240	Nd:YAG rod 1.3 µm in mirror holder			1	
474 5241	Mirror SHG 1.3 µm			1	
474 5290	Coloured glass filter KG5, 50 x 50 x 3 mm			1	

Cat. No.	Description	P5.8.6.2	P5.8.6.3	P5.8.6.4	P5.8.6.5
474 1081	Modul G InGAAS photodetector			1	
474 110	Module P - Crystal for passive q-switch operation				1
474 1804	Light Chopper on Carrier with Controller				1*
474 264	Upgrade Kit for Active q-Switch				1*

* additionally recommended

Experiment P5.8.6.2 builds a diode pumped Nd:YAG laser ground up. First the pump diode laser is characterized. Then the process of optical pumping and the emitted spontaneous fluorescence are analysed spectrally and temporally by modulation and changing the wavelength of the pump laser leading to the Einstein coefficients. In a third step the laser operation is initiated by adding the second cavity mirror. The laser threshold and efficiency are determined and by modulating the pump laser diode the so called spiking effect demonstrated. By changing the length of the laser cavity the stability criterion is verified.

Experiment P5.8.6.3 enhances the basic set-up of the diode pumped Nd:YAG laser (P5.8.6.2) by a KTP crystal module placed into the laser cavity leading to a frequency doubled green (532 nm) visible output. By adding the optional adjustable iris the transverse mode structure can be controlled for various TEM structures down to TEM00.

Experiment P5.8.6.4 is a variation of P5.8.6.3, but using differently coated mirrors and differently cut KTP, the Nd:YAG laser operates at 1320 nm and the frequency doubled visible light is red at a wavelength of 660 nm.

In the experiment P5.8.6.5 the basic set-up of the diode pumped Nd:YAG laser (P5.8.6.2) is enhanced by a passive saturable absorber module placed into the laser cavity. The initial absorption of the Cr:YAG crystal prevents continous laser oscillation. Build-up of inversion will saturate the absorber and repeatedly create a giant and short laser puls. Optionally an active Q-switch can be used to trigger such a pulse externally.

Pulsed diode laser (P5.8.6.6)

P5.8.6

SOLID STATE LASER

P5.8.6.6
Pulsed diode laser

P5.8.6.7
Diode pumped
Nd:YVO4 micro laser

Cat. No.	Description	P5.8.6.6	P5.8.6.7
474 1031	Module B - Collimating optics on carrier MG-65 with Melles Griot	1	1
474 6412	Polarisation analyzer 40 mm	1	
474 4025	IR converter screen 0.8 - 1.6 µm	1	1
474 6414	Photodetector for Pivot Arm	1	
531 183	Digital multimeter 3340	1	
474 5464	Oscilloscope, Dual Channel, Digital	1	1
575 24	Screened cable, BNC/4 mm	1	
501 091	BNC T adapter	1	
474 341	BNC load resistor 50 Ohm	1	
474 309	Controller for Pulsed Laser Diode	1	
474 5428	Pulsed Diode Laser Module 908 nm	1	
474 5442	Profile rail, 500 mm	1	1
474 121	Swivel Unit with Carrier	1	
474 2114	Adjustment holder, 4 axes, rotary insert	1	
474 251	Transport and Storage Box #01	1	1
474 7109	LIT: Pulsed Diode Laser	1	
474 5460	Laser Power Meter	1*	
474 5463	Laser Energy Sensor, 300 nJ ... 600 µJ	1*	
474 104	Focussing Optics, f = 60 mm		1
474 241	Monolithic Nd:YVO4 + KTP Core Laser		1
474 5453	Crossed Hair Target in C25 mount		1
474 107	Filter Plate Holder		1
468 74	Filter, infrared		1
474 306	Photodetector signal conditioning box		1
474 108	SiPIN photodetector		1
501 06	HF-Cable, BNC-BNC, 1.5 m		1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m		1

Cat. No.	Description	P5.8.6.6	P5.8.6.7
474 302	Controller for Diode Laser		1
474 102	Diode Laser Head with Adjustment Holder		1
474 122	Optics cleaning set		1
671 9700	Ethanol, absolute, 250 ml		1
474 7127	LIT: Micro Laser		1

* additionally recommended

Pulsed diode lasers emit short pulses with a pulse width of 10 ... 100 nanoseconds. Similar to a flash lamp the laser can emit a very high peak power for a short time. Experiment P5.8.6.6 analyses the temporal and spatial properties of a diode laser emitting a peak power of 70 W within a pulse width of 100 ns. The electrical as well as optical pulse is monitored on an digital oscilloscope.

Green laser light is still widely produced by optical pumping and frequency doubling. Within this experiment P5.8.6.7 a so called GCL (green core laser), consisting of a Neodymium Yttrium Vanadate (Nd:YVO4) crystal which is cemented to a KTP crystal is used. Its small size of only 1.3 mm x 1.3 mm x 3 mm justifies the term „Micro Laser". The GCL is pumped by a diode laser as known from the optical pumping of the Nd:YAG Laser (P5.8.6.2).

P5.8.7

OPTICAL FIBRES

P5.8.7.1
Fibre laser

P5.8.7.4
Erbium doped fibre amplifier

Fibre laser (P5.8.7.1)

Cat. No.	Description	P5.8.7.1	P5.8.7.4
474 104	Focussing Optics, f = 60 mm	1	
474 5308	Bandpass filter 1.5 µm in C25	1	
474 190	Fused WDM Coupler 980/1550 nm	1	
474 191	Fibre collimator with ST connector, left	1	
474 192	Fibre collimator with ST connector, right	1	
474 194	ST coupler in C25 mounted	1	
474 1898	Erbium Doped Fibre Module, 8 m	1	
474 246	Output coupling module	1	
474 5293	SM Fibre 100 m on drum, ST connector	1	
474 5296	Fibre Patch Cable ST/ST, Length 0.25 m	3	
474 5297	Fibre Patch Cable ST/ST, Length 1 m	1	
474 4025	IR converter screen 0.8 - 1.6 µm	1	1
474 306	Photodetector signal conditioning box	1	1
474 108	SiPIN photodetector	1	
474 1084	InGAAS Photodetector	1	1
474 5464	Oscilloscope, Dual Channel, Digital	1	1
501 06	HF-Cable, BNC-BNC, 1.5 m	1	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	1	2
474 302	Controller for Diode Laser	1	2
474 5426	Diode laser module, ST fibre connector	1	
474 5442	Profile rail, 500 mm	1	2
474 5444	Profile Rail, 1000 mm	1	
474 209	Mounting Plate C25 with Carrier 20 mm	1	2
474 251	Transport and Storage Box #01	2	1
474 7110	LIT: Fibre Laser	1	
474 189	Erbium doped fibre 2 m module, ST connect	1*	
474 1894	Erbium Doped Fibre Module, 4 m	1*	
474 1896	Erbium Doped Fibre Module, 16 m	1*	
474 5278	Passive mode locker module 1.5 µm	1*	
474 5279	Optical isolator, 1.5 µm, SM Fiber, ST	1*	
474 5254	Collimating Optics, high NA		1
474 1036	Collimating Optics on Carrier		1
474 151	Coupling Optics, XY- Adjustment Holder		1
474 156	Dichroic Beam Combiner 980/1550 nm		1
474 157	Erbium doped fibre 17 m with holder		1
474 321	Si PIN Photodetector		1
474 5304	Diode Laser Head 980 nm		1
474 5305	Diode Laser Head 1550 nm		1
474 211	Adjustment holder, 4 axes, carrier 20 mm		2
474 7120	LIT: Erbium doped Fibre Amplifier (EDFA)		1

* additionally recommended

In the experiment P5.8.7.1, an Erbium doped fibre is used as active material. Connected to a pump laser, the fluorescence from the erbium fiber is analysed. Before the laser operation at 1.5 µm is studied, the lifetime of the exited state is measured. To form a ring laser a WDM is used to couple the pump light into the fibre and to close the laser ring structure. The ring is opened where a thin glass plate couples a small fraction of the clockwise (cw) and counter clockwise (ccw) laser modes towards a detector.

Experiment P5.8.7.4 realises an optical amplifier. An Erbium doped fiber is pumped below laser level, incoming light from a laser diode triggers stimulated emission and the light intensity is increased.

Glass fibre optics (P5.8.7.3)

P5.8.7

OPTICAL FIBRES

P5.8.7.2
Plastic optical fibre (POF)

P5.8.7.3
Glass fibre optics

Cat. No.	Description	P5.8.7.2	P5.8.7.3
474 5229	Plastic Optical Fibre, 10 m	1	
474 5230	Plastic Optical Fibre, 20 m	1	
474 5231	Plastic Optical Fibre, 30 m	1	
474 5232	F-SMA Connector Mounting Set	1	
474 6425	Coupler F-SMA for POF	2	
474 124	Plastic Fibre Holder with XY-Adjustment	1	
474 304	Dual Channel Receiver	1	
474 125	Dichroic Beam Splitter Unit	1	
474 5464	Oscilloscope, Dual Channel, Digital	1	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	2	1
474 305	Dual Channel LED Transmitter	1	
474 5424	Dual LED - FSMA	1	
474 5442	Profile rail, 500 mm	1	1
474 209	Mounting Plate C25 with Carrier 20 mm	2	
474 251	Transport and Storage Box #01	1	1
474 7118	Manual Plastic Fibre Optics	1	
474 1036	Collimating Optics on Carrier		1
474 151	Coupling Optics, XY- Adjustment Holder		1
474 152	Bare Fibre Holder with Translation Stage		1
474 154	Bare Fibre Holder on Rotation Stage		1
474 5227	Optical Glass Fibre, 1000 m multimode		1
474 6420	Optical Fibre Cleaver and Breaker		1
474 6421	Adjustable Plastic Cover Stripper		1
474 4025	IR converter screen 0.8 - 1.6 µm		1
474 306	Photodetector signal conditioning box		1
474 216	SiPIN Photodetector, Mounting Plate C25		1

Cat. No.	Description	P5.8.7.2	P5.8.7.3
501 06	HF-Cable, BNC-BNC, 1.5 m		1
474 302	Controller for Diode Laser		1
474 1022	Diode Laser Head with Adjustment Holder		1
474 7119	Manual Glass Fibre Optics		1
474 5226	Optical Glass Fibre, 1000 m monomode		1*
474 5295	Multimode optical fibre 5000 m, 50/125 µm, on drum		1*

* additionally recommended

Experiment P5.8.7.2 shows the properties of a plastic optical fiber and shows the basics of wavelength multiplexing and demultiplexing. A red and a blue LED are simultaneously coupled into the fiber and separated at the end.

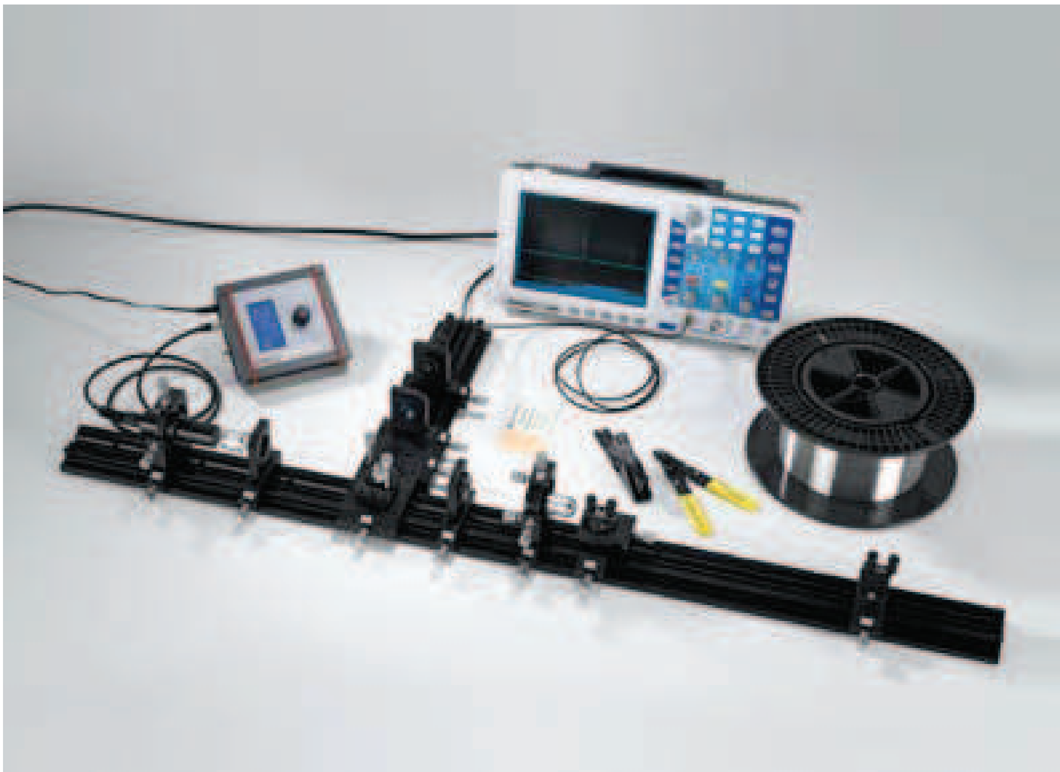
Experiment P5.8.7.3 introduces to glass fibre optics. Within this experiment the diode laser itself will be characterised with respect to its output power as function of its temperature and injection current. The spatial intensity distribution is measured by means of the provided rotation stage. Cutting and preparing the fibre is part of the practical training. The light of the diode laser is coupled into the fibre by means of adjustable microscope objectives. The coupling efficiency is monitored with the photodetector detecting the light coming out at the end of the fibre. The intensity distribution of the light emerging at the end of the fibre is measured and the numerical aperture determined. By modulating the diode laser by means of the provided microprocessor controlled device the time of flight inside the fibre will be measured. From the results either the length of the fibre or the speed of light is calculated.

P5.8.7
OPTICAL FIBRES

P5.8.7.5
Optical time domain reflectometry (OTDR)

P5.8.7.6
Signal transmission via glass fibre

P5.8.7.7
Fibre Optics Workshop



Optical time domain reflectometry (OTDR) (P5.8.7.5)

Cat. No.	Description	P5.8.7.5	P5.8.7.6	P5.8.7.7
474 1036	Collimating Optics on Carrier	1		
474 104	Focussing Optics, f = 60 mm	1		
474 5274	Quarter wave plate, C25	1		
474 230	Beam splitter module	1		
474 151	Coupling Optics, XY- Adjustment Holder	1		
474 150	Bare Fibre Holder with Carrier	1		
474 152	Bare Fibre Holder with Translation Stage	1		
474 5227	Optical Glass Fibre, 1000 m multimode	1		1
474 6420	Optical Fibre Cleaver and Breaker	1		
474 6421	Adjustable Plastic Cover Stripper	1		1
474 4025	IR converter screen 0.8 - 1.6 µm	1		
474 331	Photodetector, Ultrafast with Amplifier	1		
474 5464	Oscilloscope, Dual Channel, Digital	1	1*	
501 06	HF-Cable, BNC-BNC, 1.5 m	1		
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	1		
474 309	Controller for Pulsed Laser Diode	1		
474 5428	Pulsed Diode Laser Module 908 nm	1		
474 5442	Profile rail, 500 mm	1		
474 5444	Profile Rail, 1000 mm	1		
474 209	Mounting Plate C25 with Carrier 20 mm	2		
474 2114	Adjustment holder, 4 axes, rotary insert	1		
474 251	Transport and Storage Box #01	1	1*	
474 7121	Manual OTDR	1		
474 6426	Optical Fibre Transmitter, ST Connectors		1	
474 6427	Optical Fibre Receiver, ST Connectors		1	
474 5228	Optical Multimode Glass Fibre, 5000 m		1	
773 629	Fibre Patch Cable MM, 1.0 m		2	
501 091	BNC T adapter		1	
474 341	BNC load resistor 50 Ohm		1	

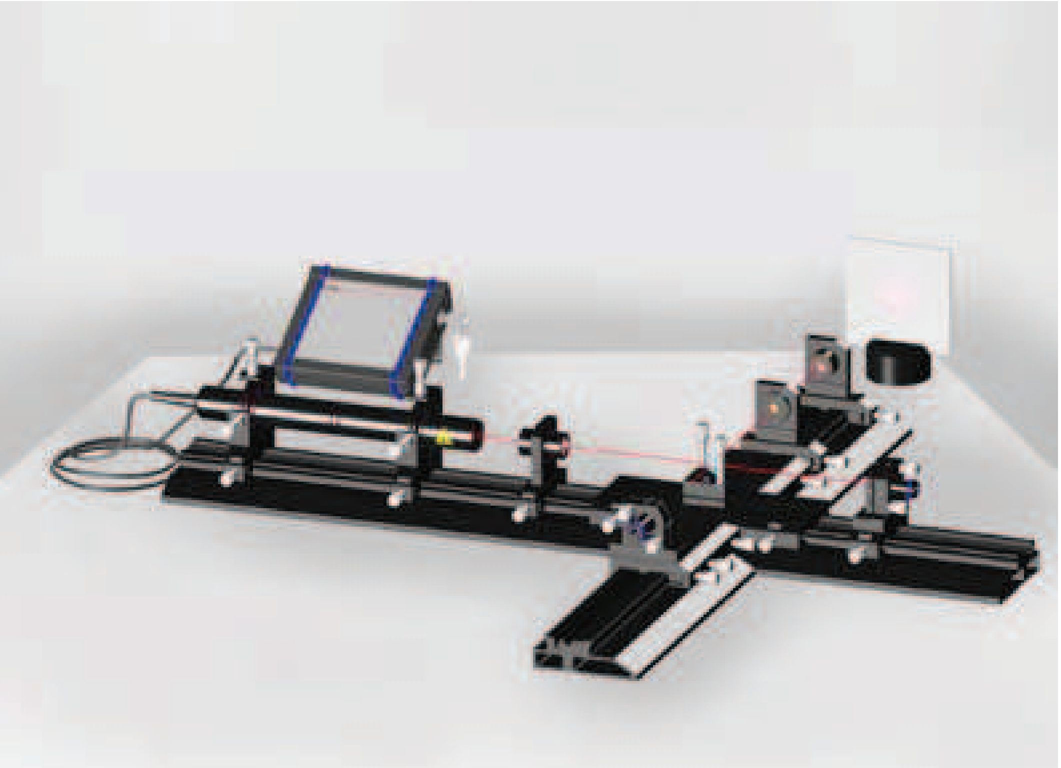
Cat. No.	Description	P5.8.7.5	P5.8.7.6	P5.8.7.7
474 5465	CCD Camera, coloured		1	
474 5466	CD player incl. music CD		1	
474 5467	Flat panel TV 19 inch		1	
474 7122	Manual Optical Data Transmission		1	
474 184	Fibre coupling module		1*	
474 5479	Hot Melt Assembly Kit			1
474 5476	HotMelt polishing unit			1
474 5477	Hotmelt ST connector, set of 60			1
474 7123	Manual Fibre Optics Workshop			1
474 6423	Splicing tubes 60 mm, set of 250			1*
474 5473	Fusion Splicer, SM & MM			1*
474 5474	High performance fibre cleaver & breaker			1*

* additionally recommended

Experiment P5.8.7.5 shows the properties of optical time domain reflectometry (OTDR) in a fiber optic setup. Optical and mechanical imperfections within the fibre and fibre links or mechanical stress all lead to power losses. OTDR is the tool to analyse and locate such imperfections in optical fibres. The basic idea is to feed a light signal into the fibre and monitor the occurrence of light echoes.

Within the experiment P5.8.7.6, a data transmission line will be set-up with an optical fibre with a length of 5 km and the transmission of video as well as audio signals are demonstrated and studied. The set-up comes with a colour CCD video camera and a CD-player as an audio source and a TV screen as a monitor. By means of an optional fibre coupling module the optical signals can be monitored and analyzed and the sensitivity against misalignment studied.

The main goal of the experiment P5.8.7.7 is the connectoring of optical glass fibres with ST connectors. Although a variety of other fibre connectors exist the process of connectoring however remains the same. Another major technology is the welded connection of bare fibres by means of the fusion splicing technology.



Michelson laser interferometer - Basic setup (P5.8.8.1_b)

P5.8.8

TECHNICAL APPLICATIONS

P5.8.8.1
Michelson laser interferometer

Cat. No.	Description	P5.8.1.1 (b)	P5.8.8.1 (c)	P5.8.8.1 (d)
474 5216	Plano-Convex lens f = 40 mm, C25 mount	1	1	1
474 5219	Biconcave Lens f = -5 mm, C25 mount	1	1	1
474 5220	Biconcave Lens f = -10 mm, C25 mount	1	1	1
474 5246	Laser Mirror, flat, M16 Mount	2	2	2
474 113	Laser Mirror Adjustment Holder, left	2	2	2
474 5247	Beam splitter plate 1:1 @ 632 nm, mounted	1	1	1
474 115	Carrier cross-piece, adjustable stage	1	1	1
474 5453	Crossed Hair Target in C25 mount	1	1	1
474 147	EXP10-Modul H, Schirm auf Reiter	1	1	1
474 306	Photodetector signal conditioning box	1	1	1
474 108	SiPIN photodetector	1	1	1
474 5464	Oscilloscope, Dual Channel, Digital	1	1	1
501 06	HF-Cable, BNC-BNC, 1.5 m	1	1	1
474 3034	HeNe Laser High Voltage Supply	1	1	1
474 5421	HeNe Pilot Laser Ø 30 mm	1	1	1
474 5442	Profile rail, 500 mm	4	4	4
474 5454	Laser adjustment holder, soft ring 30 mm, carrier 20 mm	2	2	2
474 209	Mounting Plate C25 with Carrier 20 mm	4	4	4
474 122	Optics cleaning set	1	1	1
671 9700	Ethanol, absolute, 250 ml	1	1	1
474 251	Transport and Storage Box #01	2	2	2
474 7112	LIT: Michelson Interferometer	1	1	1
474 267	Set of spare parts	1*	1*	1*
474 5248	Polarising beam splitter cube		1	1
474 403	Triple Reflector in 1 inch mount		2	2
474 144	Beam Displacer 5 mm		1	1
474 146	Fringe detection unit		1	1

Cat. No.	Description	P5.8.8.1 (b)	P5.8.8.1 (c)	P5.8.8.1 (d)
474 148	Dial Gauge 5 mm / 1 µm, Carrier 20		1	
474 149	Triple Reflector with Translation Stage		1	
474 308	Photodetector Preamplifier		1	1
474 3111	Fringe Counter		1	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m		2	2
474 330	Stepper Motor Controller, 1 Axis, USB			1
474 145	Motorised Translation Stage 50 mm			1
	additionally required: PC with Windows XP/Vista/7/8/10 (x86 or x64)			1

* additionally recommended

The setup of the famous Michelson interferometer in experiment P5.8.8.1 is accomplished by the modern modules and components. As light source a two mode Helium Neon laser is used. The contrast function is measured for different path lengths. From these results the coherence length of the probe laser is determined. The interference fringes are either displayed by the translucent white screen or their intensity is measured by means of an oscilloscope. By adding a variety of technical components the interferometer can be upgraded to a technical interferometer to train the calibration of CNC machines.

P5.8.8

TECHNICAL APPLICATIONS

P5.8.8.2
Laser range finder

P5.8.8.3
Laser vibrometer

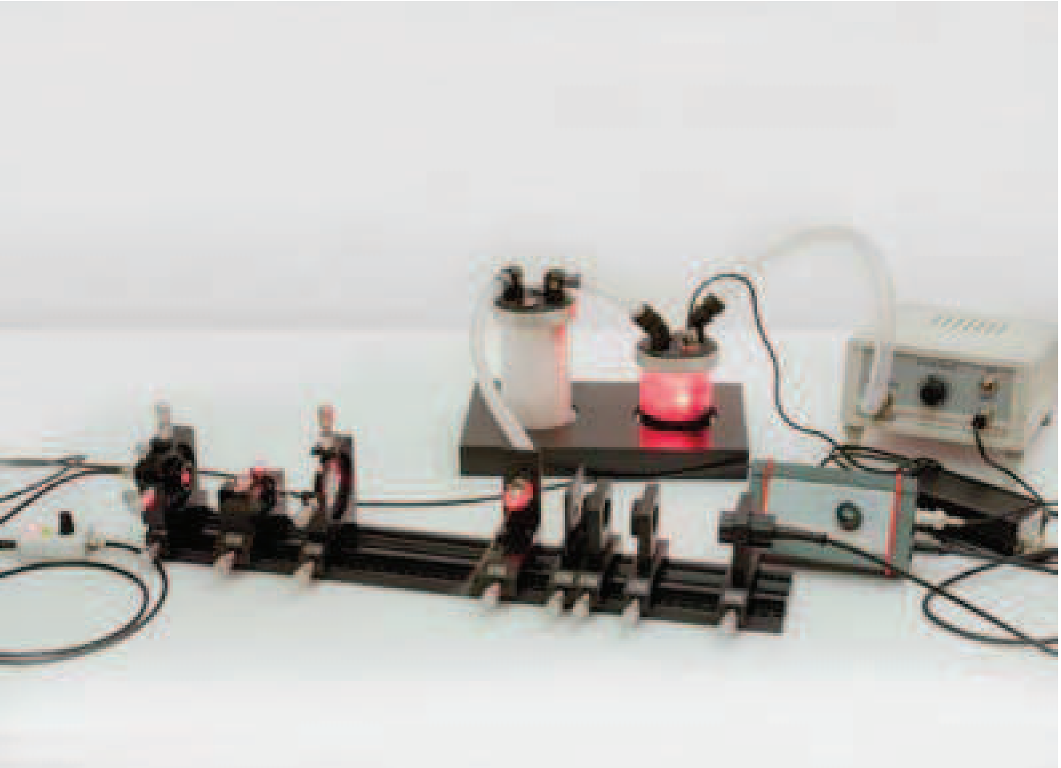
Laser vibrometer (P5.8.8.3)

Cat. No.	Description	P5.8.8.2	P5.8.8.3
474 1031	Module B - Collimating optics on carrier MG-65 with Melles Griot	1	
474 104	Focussing Optics, f = 60 mm	1	1
474 4025	IR converter screen 0.8 - 1.6 µm	1	
474 331	Photodetector, Ultrafast with Amplifier	1	
474 5464	Oscilloscope, Dual Channel, Digital	1	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	1	
474 309	Controller for Pulsed Laser Diode	1	
474 5428	Pulsed Diode Laser Module 908 nm	1	
474 5442	Profile rail, 500 mm	2	1
474 209	Mounting Plate C25 with Carrier 20 mm	1	1
474 211	Adjustment holder, 4 axes, carrier 20 mm	1	1
474 251	Transport and Storage Box #01	1	1
474 7113	LIT: Laser Range Finder	1	
474 5220	Biconcave Lens f = -10 mm, C25 mount		1
474 5320	Quarter wave plate, C25		1
474 206	Speaker mounted on carrier 20 mm		1
474 207	Beam Recombiner Assembly		1
474 208	Beam Splitting Assembly		1
474 2071	Rider with tilted mirror		1
474 313	Heterodyne Mixer and AOM driver		1
474 411	Acoustic optic modulator AOM		1
522 621	Function generator S 12		1
474 3312	Fast photodetector for laser use		2
501 06	HF-Cable, BNC-BNC, 1.5 m		3
575 24	Screened cable, BNC/4 mm		1

Cat. No.	Description	P5.8.8.2	P5.8.8.3
474 302	Controller for Diode Laser		1
474 5431	Laser 532 nm, singlemode		1
474 7114	LIT: Laser Vibrometer		1

In experiment P5.8.8.2 a high energy pulsed laser diode is collimated and aimed at the target. The short laser pulse (30 ns) travels with the speed of light. The scattered light is detected by a Si-PIN photodiode after passing the receiver lens. Based on the time of flight and the known speed of light the distance to the target is calculated.

The laser vibrometer in experiment P5.8.8.3 demonstrates the working principle of a contactless measurement of vibrations of a target. Using a heterodyne setup one optical detector is sufficient to realise a quadrature forward / backward counter.The back scattered and Doppler shifted light is coupled back to the interferometer and superimposed with the reference beam. The frequency of the reference beam is shifted by a Bragg cell. The subsequent signal amplifiers can be AC coupled allowing a much higher gain in a simple way than a Michelson interferometer.



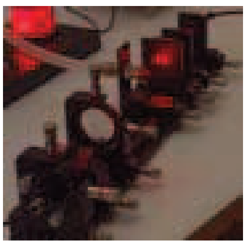
Laser Doppler anemometer (P5.8.8.4)

P5.8.8

TECHNICAL APPLICATIONS

P5.8.8.4
Laser Doppler anemometer

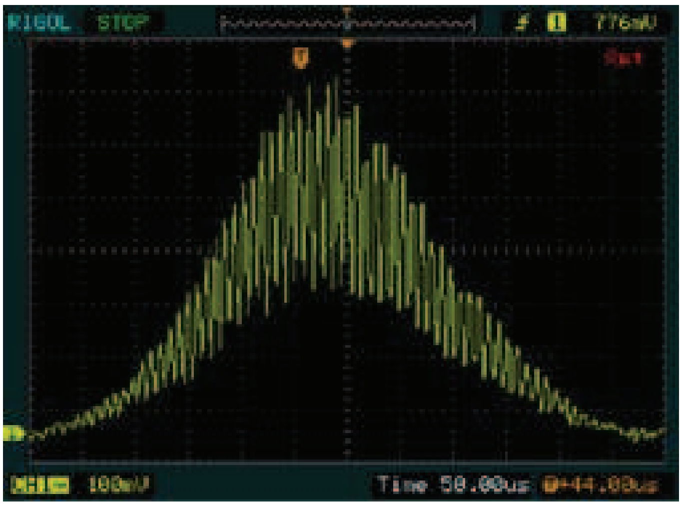
Cat. No.	Description	P5.8.8.4
474 104	Focussing Optics, f = 60 mm	2
474 107	Filter Plate Holder	1
474 187	LDA Beam Splitting Assembly	1
474 1876	LDA Beam Deflection and Focussing	1
474 188	Ultrasonic particle seeder	1
474 315	Ultrasonic Particle Nebuliser	1
474 331	Photodetector, Ultrafast with Amplifier	1
474 5464	Oscilloscope, Dual Channel, Digital	1
501 06	HF-Cable, BNC-BNC, 1.5 m	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	1
474 351	Signal Amplifier	1
474 301	Adaptive Power Supply	1
474 128	Diode laser module	1
474 5442	Profile rail, 500 mm	1
474 251	Transport and Storage Box #01	2
474 7115	LIT: Laser Doppler Anemometer	1



Laser Doppler Anemometer Setup

Laser Doppler anemometry is a non-contact optical measurement method to obtain the velocity of a flow (liquid, gas). In the experiment P5.8.8.4 a laser Doppler anemometer is assembled. A laser beam is split into two parts. Focused back to one spot, the laser beams create an interference pattern. Particles in the fluid flow move through the bright and dark zones of the pattern and the scattered light is modulated according to the speed of the particle. Alternatively, the same setup can be explained in terms of Doppler shifted light.

In this experiment, water droplets inside an air stream are used as the scattering particles. The water droplets are too small to stick to surfaces nearby and to wet them. They will just evaporate or bounce off due to surface tension.

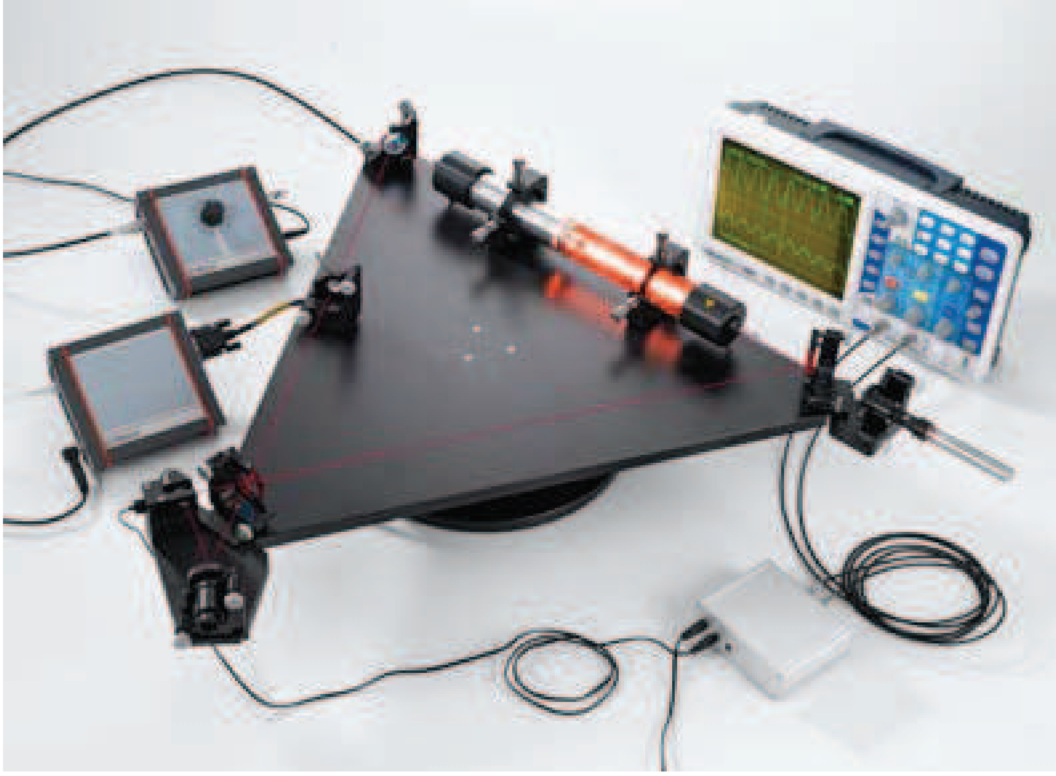


Oscilloscope signal of a water droplet passing throught the interference zone

P5.8.8

TECHNICAL APPLICATIONS

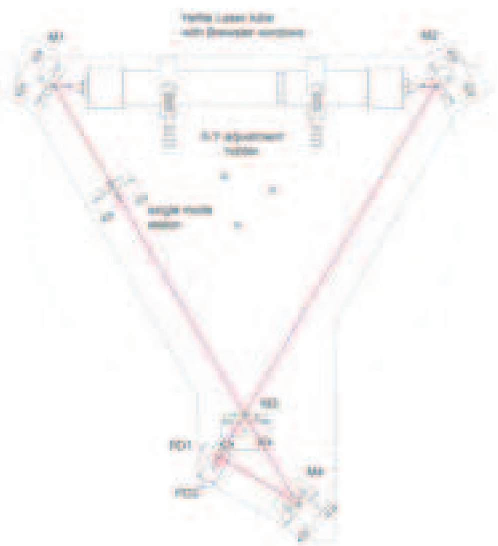
P5.8.8.5
HeNe laser gyroscope



HeNe laser gyroscope (P5.8.8.5)

Cat. No.	Description	P5.8.8.5
474 159	Gyroscope base plate	1
474 160	Rotation Unit	1
474 330	Stepper Motor Controller, 1 Axis, USB	1
474 407	Fringe Detection Unit	1
474 308	Photodetector Preamplifier	1
474 311	Fringe Up and Down Counter	1
474 346	Plug-in power supply 12 V - 2.5 A	1
474 5464	Oscilloscope, Dual Channel, Digital	1
501 061	HF-Cable, BNC-Mini BNC, 1.5 m	4
728 950	USB port isolator	1
474 303	HeNe Laser High Voltage supply, adjustable	1
474 5423	Alignment laser 532 nm	1
474 122	Optics cleaning set	1
671 9700	Ethanol, absolute, 250 ml	1
474 7116	LIT: HeNe Laser Gyroscope	1
	additionally required: PC with Windows XP or higher	1

Experiment P5.8.8.5 shows the basics of a laser gyroscope. A three-mirror mono mode HeNe ring laser is set up; using a green pilot laser adjusting the mirrors is made easy. Both CW and CCW light beams are coupled out of the resonator and fed into an interferometer, creating interference patterns. Rotating this laser, the CW and CCW cavity length is no longer equal due to special relativity, and mixing both light rays will generate a beat frequency in the kHz range. This way the absolute rotation of the laser can be measured. This is not a Sagnac style interferometer, having the laser medium inside the moving system creates a much more sensitive setup with beat frequency instead of the phase shift of a rotating Sagnac interferometer.



Optical Setup of the ring laser gyro with interferometer

Laser beam analysis (P5.8.8.6)

P5.8.8

TECHNICAL APPLICATIONS

P5.8.8.6
Laser beam analysis

Cat. No.	Description	P5.8.8.6
474 1036	Collimating Optics on Carrier	1
474 5266	Collimating cylindrical lens f = 20 mm	1
474 5267	Collimating cylindrical lens f = 80 mm	1
474 5263	Beam expander 6x	1
474 5470	Beammaster BM-7S	1
474 5418	Diode Laser Module, 532 nm	1
474 5420	Dimo diode laser module, 630 nm (red)	1
474 5442	Profile rail, 500 mm	1
474 209	Mounting Plate C25 with Carrier 20 mm	3
474 211	Adjustment holder, 4 axes, carrier 20 mm	1
474 251	Transport and Storage Box #01	1
474 7117	Manual Laser beam analysis	1
	additionally required: PC with Windows XP or higher	1

In experiment P5.8.8.6 two different visible lasers plus collimating and expanding optics are used to demonstrate a variety of beam profile measurements with various beam shaping arrangements to show the possibilities of laser beam forming. The most important property of a laser beam is the intensity distribution in the beam. The beam profiler is no CDD type, but a knife edge type: A precise knife edge is moved through the cross-section of the laser beam. As the blade moves across the beam, it is cut from reaching the photodetector.

Using several knives with different angles on one rotating drum, the beam profile can be calculated from the time responses when the knives pass through the beam.

Optical setup of a semiconductor laser diode

PHYSICS CHEMISTRY BIOLOGY ENGINEERING

LD DIDACTIC

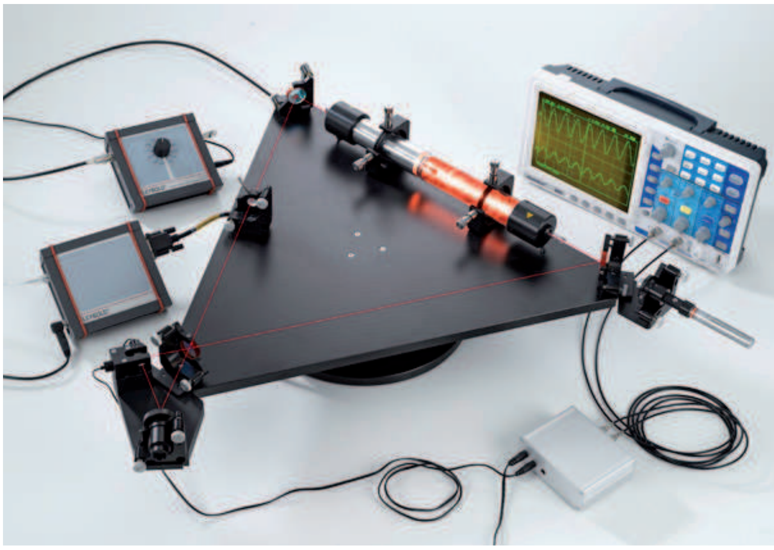
1200300EN 07.2015 LD
Technical details subject to change without notice.

CONTACT

GERMANY:

LD DIDACTIC GmbH
Leyboldstr. 1
50354 Huerth
Germany
Tel.: +49 2233 604 0
Fax: +49 2233 604 222
E-Mail: info@ld-didactic.de
www.ld-didactic.com

Systèmes **D**idactiques
Savoie Hexapole - Actipole 3 - Rue Maurice Herzog
F 73420 Viviers du Lac
Tél.: +33 (0) 4 56 42 80 70
Fax: +33 (0) 4 56 42 80 71
E-Mail: xavier.granjon@systemes-didactiques.fr
www.systemes-didactiques.fr



WWW.LD-DIDACTIC.COM

BRANDS OF THE LD DIDACTIC GROUP LEYBOLD® Feedback ELWE® TECHNIK