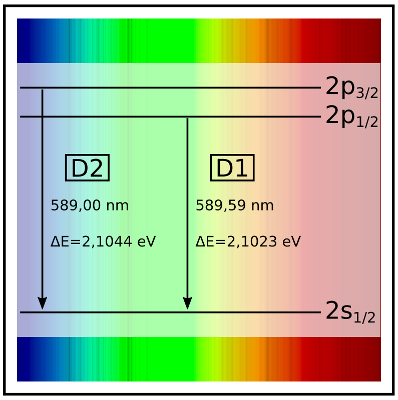
Eureca Line Scan Cameras

Application example spectroscopy

Fraunhofer lines in the solar spectrum



With a spectrometer of sufficient resolution, the Fraunhofer lines in the solar spectrum can easily be made visible. These absorption lines allow conclusions to be drawn about the chemical composition of the gas atmosphere of the sun as well as that of the earth's atmosphere. The evaluation of such lines is one of the most important tools in astronomy, also in the spectrum of other stars. Such lines in the solar spectrum were systematically examined by Joseph von Fraunhofer starting in 1814, from whom they also got their name.

Physical basics

The sun, with its surface temperature of around 6 000 Kelvin, emits light as a Planck emitter with a continuous spectrum that extends over a large wavelength range. However, certain wavelengths are weakened by resonance absorption of gases on the way of the light to the observer and then show up as dark lines in the spectrum.

The Fraunhofer C, F, G' and h lines correspond to the alpha, beta, gamma and delta lines of the Balmer series of a hydrogen atom. The lines A, B, a, Y and Z are not of solar but terrestrial origin, which means they are formed by absorption in the earth's atmosphere.

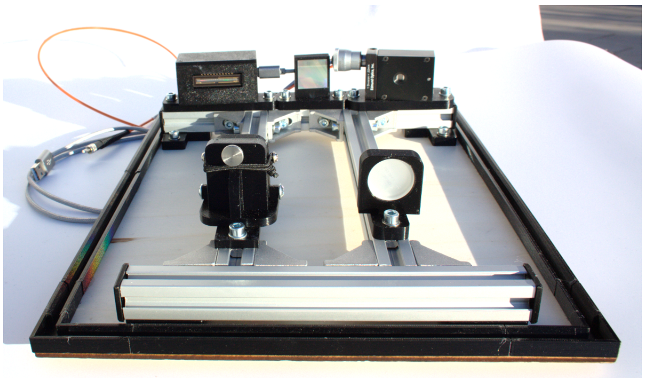
Most important Fraunhofer lines

Designation	Element	λ [nm]
A	O_2	759,370
B	O_2	686,719
C	H_α	656,281
a	O2	627,661
D1	Na	589,594
D2	Na	588,997
D3 oder d	He	587,562
E2	Fe	527,039
b1	Mg	518,362
b2	Mg	517,270
b3	Fe	516,891
b4	Fe	516,751
b4	Mg	516,733
c	Fe	495,761
F	H_β	486,134

Measurement Setup

The measurements shown here were recorded with the spectrometer that we presented in the »Czerny-Turner spectrometer application example«.

The sunlight is coupled into the spectrometer by simply holding the light guide in the direction of the sun and selecting the appropriate integration time. In order to pack the spectrometer in a portable but still light-tight manner, a spectrometer housing was built from MDF cuts and assembly parts from the 3D printer.



Spectrometer in an open housing

Laptop on closed spectrometer housing

We can provide tips and assistance for replication on request.

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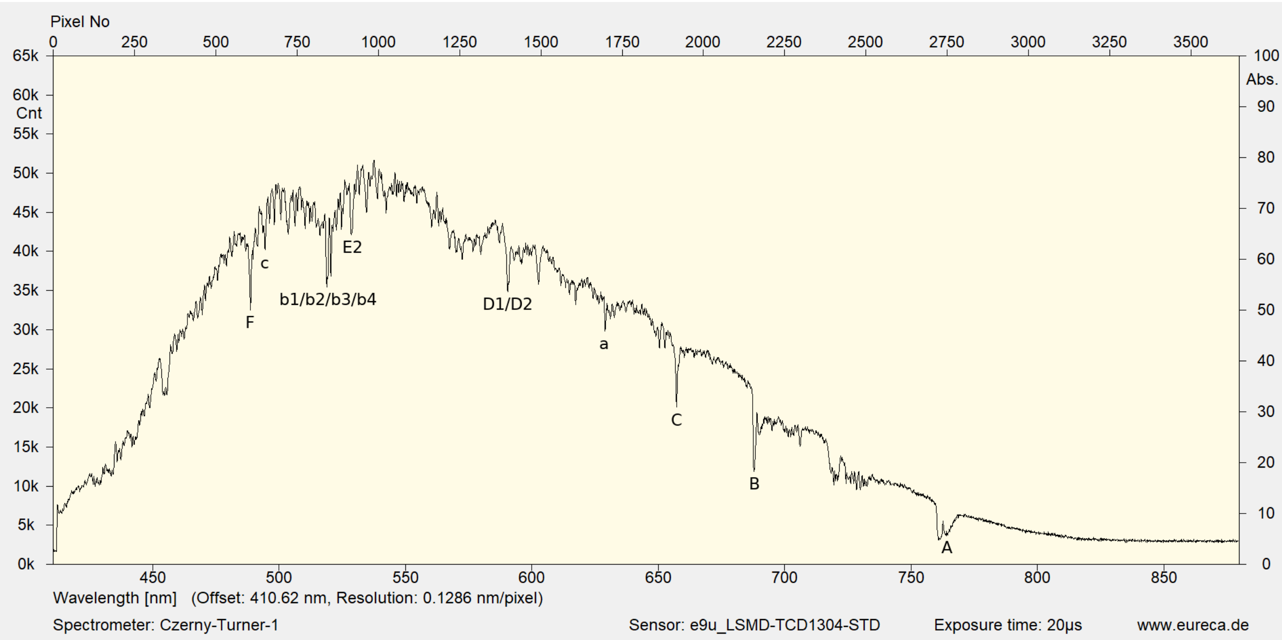
Spectrum

The spectrum shows the unprocessed raw data from the sensor. Due to the fact that the sensor has not yet been spectrally calibrated, the spectrum does not quite follow the expected form of a Planckian radiator. However, the most important Fraunhofer lines show up very clearly as dips in the sensor signal.



Solar Spectrum

The recorded data can be quite easily converted into a graph similar to the view seen through a telescope equipped with a spectrometer. For this purpose, the color of the respective wavelengths that the human eye perceives for each pixel of the spectrometer is determined and a vertical line is drawn with it. The Fraunhofer lines then appear as dark lines in this representation.

Fraunhofer lines

Didactics

The example of the solar spectrum offers, among other things, the following starting points for use in teaching:

- The understanding of spectral/resonance lines can also be developed without narrow-band spectral lamps. Above all, the well-known D-lines of sodium can be used here as an example to deduce the emitted wavelength from the energy difference of the respective states (see term scheme at the top).
- The conversion of wavelengths in nanometers to a color representation that corresponds to the perception of the human eye is a relatively complex process that requires a lot of background knowledge, including how the human eye works. We are preparing a separate application description for this exciting topic.

More on our website: https://www.eureca.de/LSC/.

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