Spectroscopy with low-cost optical fibers

Many applications, especially in schools and teaching, have to manage with a very limited budget and therefore often cannot use high-quality components. One way to reduce the cost of building a spectrometer without sacrificing the advantages of light coupling by means of optical fibers is to use low-cost optical fibers from the audio sector. When used correctly, amazingly good results can be achieved. We show this here with the example of the TOSLINK light guides in connection with the Czerny-Turner spectrometers from our application examples, which means an immediate saving of approx. 100 € for a spectrometer system.

TOSLINK (short for TOShiba-LINK) is a standardized optical fiber connection system for optical signal transmission originally developed by Toshiba. It has become widespread through its use in the digital transmission of audio signals in consumer products, where it is used, for example, for transmission between components such as CD and DVD players and audio amplifiers or D/A converters.

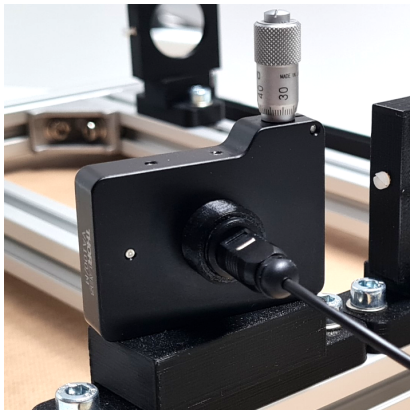
Physical basics

TOSLINK cables are offered by different manufacturers with different materials for the glass or plastic core. Infrared light (IR) between about 850 nanometers (nm) and 1550 nm is normally used to transmit the optical signals. However, due to the materials used, many of the plastic and glass materials used also offer good transmission in the visible range down to about 400 nm. Thus, a sufficiently wide usable spectral range is obtained, which can be detected by a CCD sensor as a detector.

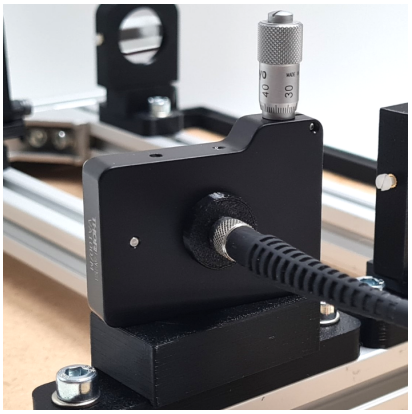
In contrast to high-quality optical fibers, which are specially manufactured for optical measuring technology and have polished end surfaces, TOSLINK optical fibers are of course not manufactured as precisely. However, by using small slit widths in the range of a few tens of micrometers when coupling the measurement signals into the spectrometer, only a small part of the light bundle exiting the light guide is used. This means that any irregularities in the light beam are hardly noticeable. In addition, by placing the light guide at some distance from the slit, further homogenization can be achieved.

Measurement setup

Two identical Czerny-Turner spectrometers with 200 mm concave mirrors were used, as they already came into action in our previous application examples. One of the spectrometers was equipped with an optical fiber from metrology (Ø 600 μm, Low OH, 0.39 NA) and the other with a TOSLINK cable.



Signal coupling with TOSLINK optical fiber



Signal coupling with low-OH optical fiber

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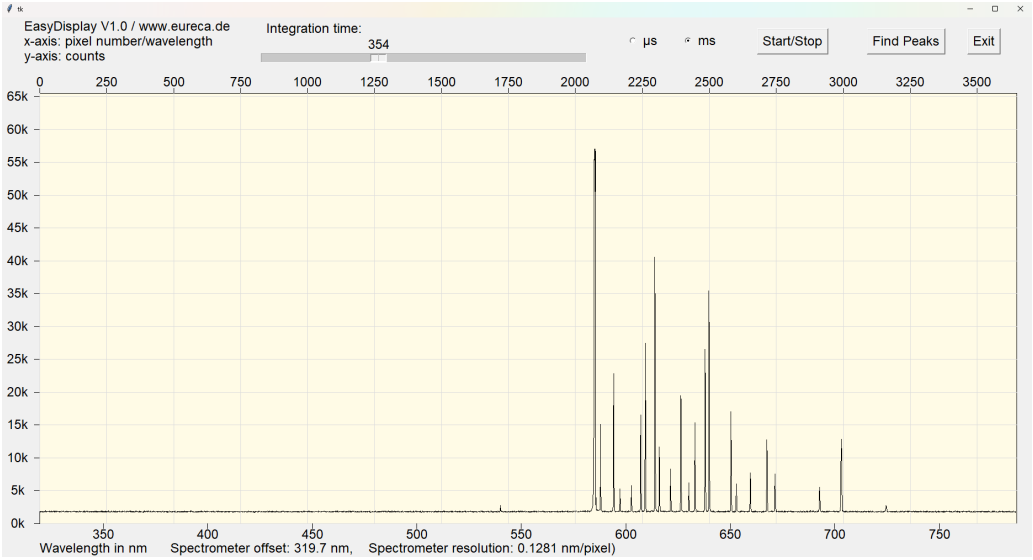
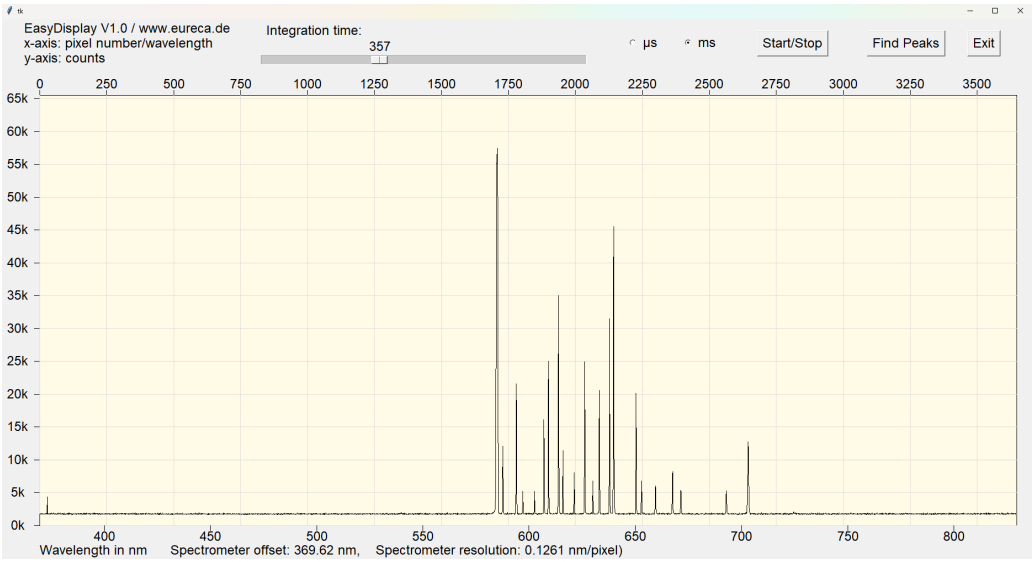
Spectra

In order to make a meaningful comparison between the two spectrometers, the spectrum of a neon glow lamp was recorded in each case as described in our application example »Spectroscopy with Neon Lamps«. Since the core diameters, numerical apertures and geometries differ when the light guide is mounted in front of the entrance slits, the signal intensities on the detectors are not necessarily the same. To still achieve comparable spectra, the slits were then adjusted to produce similar intensities on the sensors at the same integration times. Since mechanically adjustable slits were used in both spectrometers, this was very easy to do.

The neon spectrum could be recorded in both cases at acceptable integration times with small linewidth and sufficient resolution. The different positions of the neon spectrum in the measuring range result only from the fact that an adjustment to an approximately equal offset of the spectrometers was omitted.



Spectrum of the same neon glow lamp with low OH light guide



Spectrum of the same neon glow lamp with TOSLINK light guide

Didactics

The measurement data show that at least when recording the spectrum of neon glow lamps, the inexpensive TOSLINK cable can be used without loss of measurement quality. In this way, the energy levels of neon and the transitions in emission can be discussed. But also other interesting spectroscopic experiments are in a similar spectral range, such as the measurement of the spectra of LEDs and laser diodes, the transmission of solutions or the reflection of colored surfaces.

Whether the use of the inexpensive TOSLINK cables is also useful in other spectral ranges, such as further towards near infrared or near ultraviolet, we will still clarify in further experiments and publish in future application descriptions.

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