TECHNICAL NOTE TN-04

Problem	**What causes straylight in spectral imaging? Objective and target as a source of stray light?**	**Date**	2nd of July 2015
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1. Introduction

Straylight can be defined as unwanted light power caused by out of field of view sources, mechanical structures or non-perfect optical surfaces. It can also be thermal emission emanating inside the optical system. In imaging spectral instruments this stray light is measured at the detector and it can, due to its random nature mix with actual measurement signal. In general stray light does not form an image but is fog like contribution reducing spatial and spectral resolution.

Flare is defined as reflected light; from lens elements, metal surface, etc. Flare usually appears as non-uniform haze or bright spots on the detector and it often has the shape of the aperture. The use of uncoated or poor quality coatings makes lenses more prone to flare.

Ghost images are seen as out-of-focus like secondary images usually caused by reflections from lens surfaces.

Stray light in imaging spectrographs is more dominant error than in single channel spectrographs. This due to the fact that in imaging spectrograph the spectrum is imaged from one narrow part along the slit (spatial axis) but stray light contribution is coming from the whole length of the slit.

There are a few distinctive sources that should be considered. This document present these and possible corrections.

Sources of stray light and corrections

2.1 Target

Due to operation principle the spectral camera is seeing only a narrow line at the target (sample). This line is selected by the input slit of the spectrograph. However, the fore optics is transferring the image of the whole scene to the slit area as 2 –dimensional image. Part of this light is absorbed by the black slit (it is not perfect absorber) and part is reflected back to objective and target direction. There are two possible sources of stray light:

1. Light reflected back from the slit may cause additional reflection inside the objective lens surfaces
2. Light reflected back from the slit can contribute to the illumination on the target. Bright source outside the field of view can therefore contribute spectrally to dark areas.

Corrective action: One should have a black baffle limiting the field of view to the target and thus prevent signal outside the slit field of view entering the objective. If possible one should only illuminate a very narrow line from the sample surface area.

2.2 Objective lens

Spectrograph wavelength range is usually wider than the design range of common objective lens. Objectives designed for standard machine vision inspection are usually manufactured only for the visible wavelength range having coatings optimized from 400 to 700 nm region. Any light penetrating the objective from target direction or outside this field of view can have multiple reflections inside the lens group and occasionally enter the slit and contribute to measurement signal.

Corrective action: One should use objective lens that is designed and coated to the wavelength range of the spectrograph.

2.3 Spectrograph

The spectrograph has a specific numerical aperture (F-number) defining the maximum angle of rays that can be transferred through its optics without vignetting. Any rays entering the spectrograph in an angle greater than this will end up to baffles, lens edges or walls of the spectrograph interiors. Commercial objective lenses may be designed for lower F-number (meaning higher incoming angle) than the spectrograph. This may cause additional straylight due to overfilling the spectrograph numerical aperture.

Corrective action: One should always use the same F-number in objective lens than in the spectrograph.

2.4 Camera

The CCD reflects light back to spectrograph. The amount depends on the reflectivity of the detector element and possible windows / Ar-coatings. This light may in some occasions introduce unwanted reflections from the lenses and grating that contribute to straylight.

If there are mirror like surfaces like bonding pads, frame transfer area etc… these can in some case add contribution to ghost images or flare.

Corrective action: baffles that prevent these reflections (not always possible).