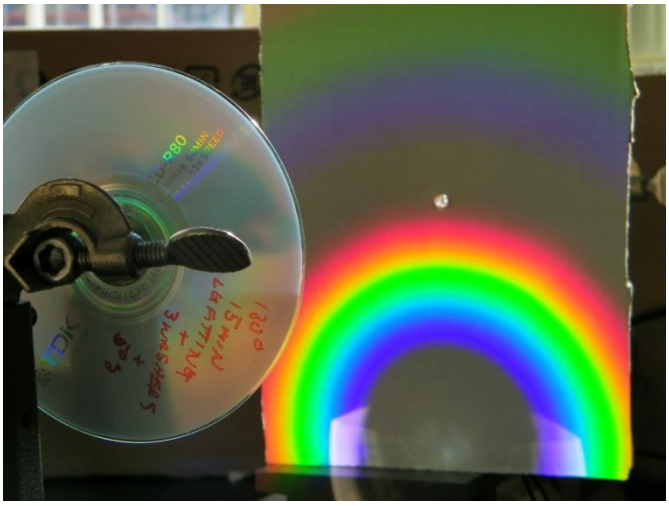
A Novel Low-Cost, Low-Power, Durable Circular Diffraction Spectrometer

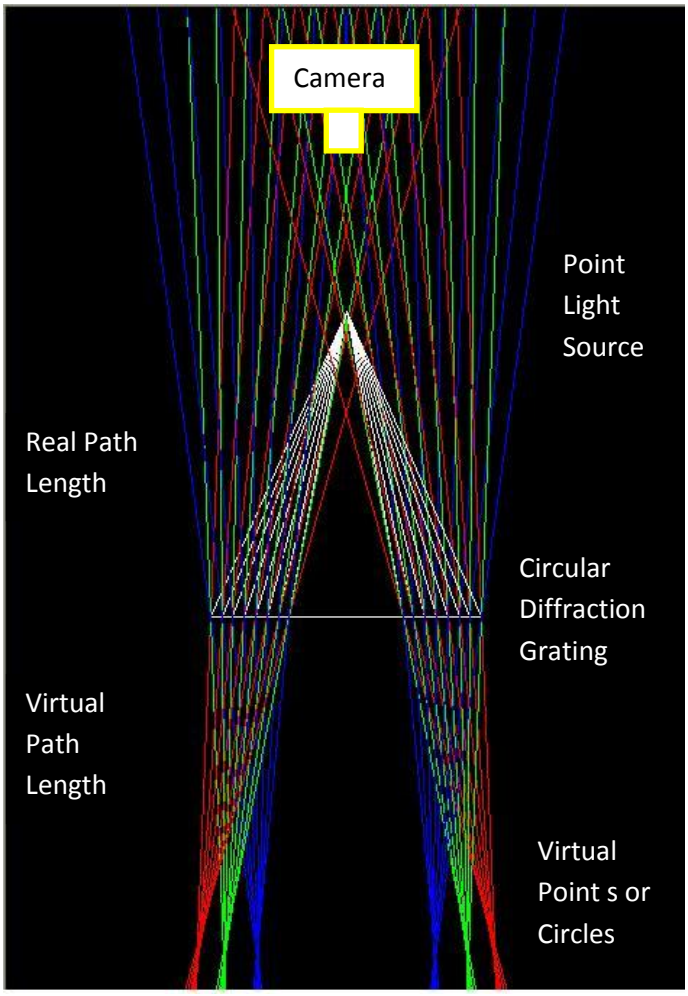
The development of circular diffraction spectrometers is motivated by the need for low-cost instruments that can be used in the field under harsh conditions. These spectrometers should be durable, inexpensive and require less than 15 watts of power to operate. We already have several working prototypes of a UV-Vis circular diffraction spectrometer and we are gearing up to market these to schools at one tenth the cost of current spectrometers in the summer of 2012. We are also now developing fluorescence spectrometers. Note the University of Maine owns this Patent Pending Technology, USPTO 61332049.

Standard hand-held spectrometers utilize an intense arc lamp for the light source which is both expensive and requires a significant amount of power. Due to the small size and type of the diffraction grating, traditional hand-held spectrometers also require an expensive high-gain CCD detector.

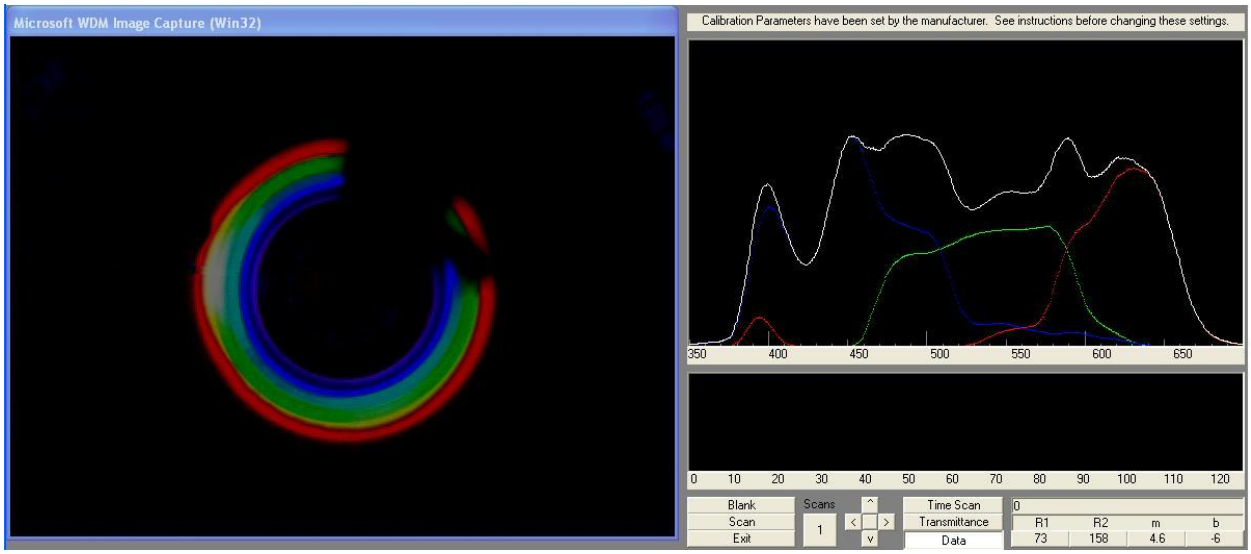
The circular diffraction spectrometers we are developing utilize a large area diffraction grating designed to collect significantly more light than a traditional spectrometer. This significantly increases sensitivity and allows less expensive lights sources and detectors to be used. Arc lamps are replaced with inexpensive and low-power fluorescent light sources and LEDs. The detector is a mass produced camera modified to function at the desired wavelengths. Furthermore large area circular diffraction gratings can be made inexpensively utilizing existing computer compact disc fabrication equipment.



The Ocean Optics UV-Vis spectrometer shown on the left relies on mirrors to increase path length, a precision made linear diffraction grating and a linear array detector. While small this component costs approximately $2000. A separate arc-lamp light source component is also needed to complete the spectrometer. It requires a separate power source and just the replacement lamps cost $700. The specially curved CD on the right is shown producing the ring spectrum of the sun. Special software has been written to integrate these rings and display the intensity versus wavelength graph.

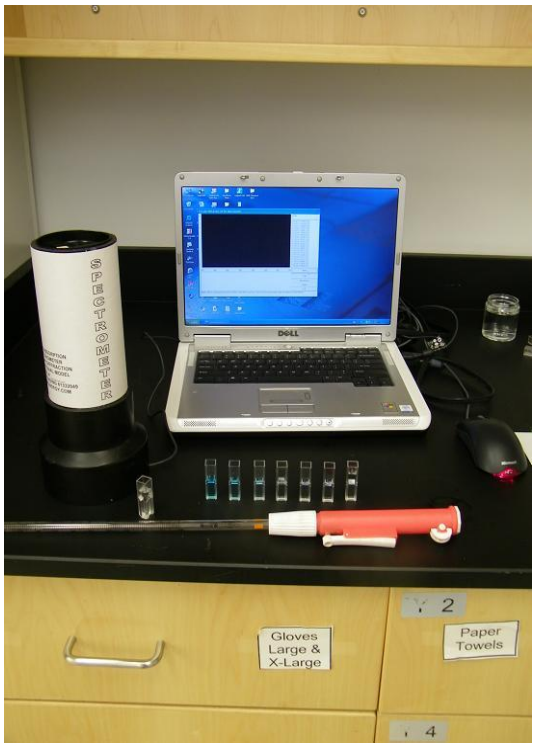


Traditional spectrometers need a large path length between the source and the detector to improve resolution. This increases the size, complexity and cost. Small spectrometers require precision made gratings and finely adjusted mirrors to achieve the path length needed. A new virtual path length approach can be utilized with circular diffraction spectrometers. The camera detector sees a virtual spectral pattern that is beyond the grating. Thus the path length is longer than the real size of the spectrometer. This means resolution is improved and more light can be captured. The figure above was generated with our own computer ray-tracing software for a first order virtual diffraction pattern. The software helps us visualize these virtual paths and is used as a tool to design circular diffraction spectrometers. For example, the software indicates the size of a second order diffraction pattern spectrometer will be even smaller than shown here and will have improved sensitivity and resolution.



A prototype circular diffraction UV-Vis spectrometer captures the circular diffraction pattern from a 2 LED light source and plots their spectrum on the right. This prototype is easily aligned from software. The prototype including the light source is completely controlled and powered through a computer USB port. The red, green and blue spectra are the signals detected from the red, green and blue sensors of the color camera. The white line is the total signal response.

A UV-Vis prototype is shown here ready for a Beer's law experiment where chemical concentrations are measured. The Circular Diffraction Fluorescence Spectrometer utilizes the same components as in this UV-Vis prototype. While this spectrometer uses the first order diffraction pattern, the fluorescence spectrometer would utilize the second order diffraction pattern, which will reduce the size of the spectrometer by a factor of two while improving sensitivity and resolution.



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