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Laser Characterization with Etalon-Based Cross-Dispersion Spectrometers

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Introduction

The use of spectrometers to characterize laser behaviour is becoming more and more prevalent as laser applications expand. Laser manufacturers and laser users often need to measure the spectra of continuous and pulsed lasers to determine properties such as linewidth, exact wavelength and wavelength drift, the occurrence of mode hopping, the presence and relative intensity of side-lobes, etc. Often these measurements must be completed in a timescale of a few milliseconds to allow fast transient behaviour to be captured.

A variety of spectrometers can be purchased to measure some or all these laser characteristics. These instruments range from scanning instruments such as Fourier Transform spectrometers and wavemeters, through conventional grating spectrometers and OSAs, to cross-dispersion spectrometers such as echelle- and etalon-based instruments. While each specific type of spectrometer has its advantages and disadvantages, we show in this article that cross-dispersion spectrometers are particularly well-suited to measuring a wide range of laser parameters. In contrast to scanning spectrometers, a cross-dispersion spectrometer can measure the entire spectrum in a "single shot", allowing the recording of the spectra of pulsed lasers, or fast repetitive measurements on continuous lasers. In addition, the use of a Fabry-Perot etalon as the main dispersing element in the spectrometer ensures high spectral resolution can be achieved in a much more compact instrument than with competing technologies.

The technology behind etalon-based cross-dispersion spectrometers

At the heart of all non-scanning spectrometers is a dispersive element that separates light into different wavelength components. The higher the dispersion of this component, the better the ability of the spectrometer to distinguish closely-spaced wavelengths in the light source. Typical dispersive elements (ranked approximately in increasing order of dispersion) are prisms, conventional diffraction gratings, echelle gratings and Fabry-Perot etalons. As laser characterization almost always involves the need to examine closely-spaced wavelengths, an etalon-based spectrometer would seem to be the obvious choice for this application. Unfortunately, the high dispersion of an etalon comes with the drawback of overlapping interference orders. While an etalon can easily separate wavelengths spaced a few picometers (pm) apart, wavelengths separated by the free spectral range (FSR) of the etalon overlap after passing through the etalon. Cross-dispersion spectrometers are used to solve this problem, as illustrated in Figure 1 below. After passing through beam-shaping optics, the light input is first dispersed *vertically* by an etalon, which provides the dispersive power to distinguish wavelengths separated by a few picometers. The output of the etalon is then cross-dispersed *horizontally* by a conventional diffraction grating to separate overlapping FSR orders and thus

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