TN2014-06: Etalons Part 1: - The Basics

Etalons are optical components based on the principle of the Fabry-Perot Interferometer. They transmit light at periodic frequencies with very narrow bandwidth, allowing them to select or control and measure the wavelength of light in a variety of situations. They are commonly used in applications such as telecommunications, lasers and spectroscopy.

Put simply, an Etalon consists of two parallel, flat, partially reflective surfaces set at a fixed distance apart, with the space between them forming the etalon cavity. This cavity is either made up of a gap (Air Spaced Etalons), or a substrate (Solid Etalons). Each type has advantages and disadvantages, which will be covered in a future Technical Note.

Multiple internal reflections occur during the reflection of light between the two surfaces. As the phase of the light changes with each reflection, light transmitted through the etalon will interfere. This gives the periodic, narrow line width, with maxima for constructive interference, and minima for destructive. The diagram below illustrates this.

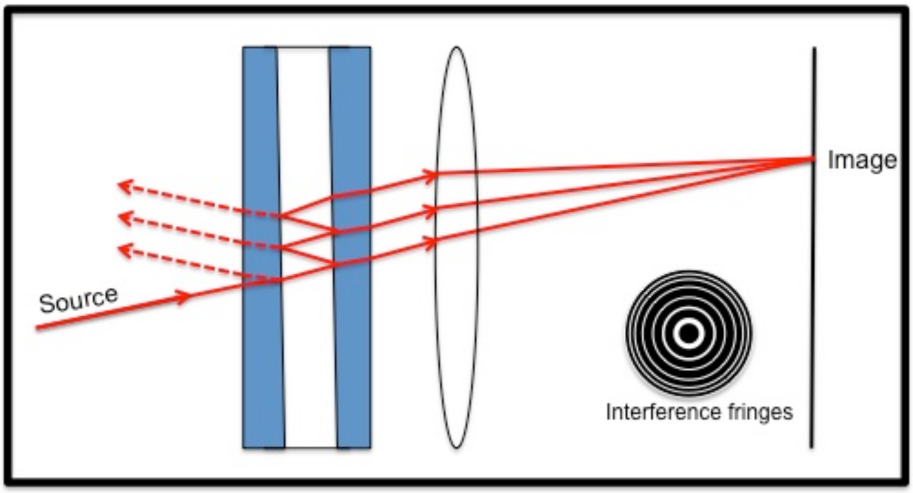

Figure TN2014-06a: Interference in an etalon

The distance between each maximum is given by the Free Spectral Range (FSR):

$$FSR = c / 2nd \text{ (frequency)} \quad \text{or} \quad FSR = \lambda^2 / 2nd \text{ (wavelength)}$$

In the equations above c is the speed of light, λ the wavelength, n the refractive index and d the etalon spacing (thickness).

The Full Width Half Maximum (FWHM) of an etalon is an expression of the bandwidth of transmission peaks. This can be related to the FSR through the finesse (F) of the etalon:

$$FWHM = FSR / \mathcal{F}$$

where, in good approximation for the Reflectivity R>0.5

$$\mathcal{F} = \pi R^{1/2} / (1-R)$$

It can easily be seen from the above equation that having an etalon with a high finesse decreases the bandwidth of the transmission, i.e. gives a narrower transmission peak. The reflectivity finesse as a function of plate reflectivity is illustrated in figure TN2014-06b below.

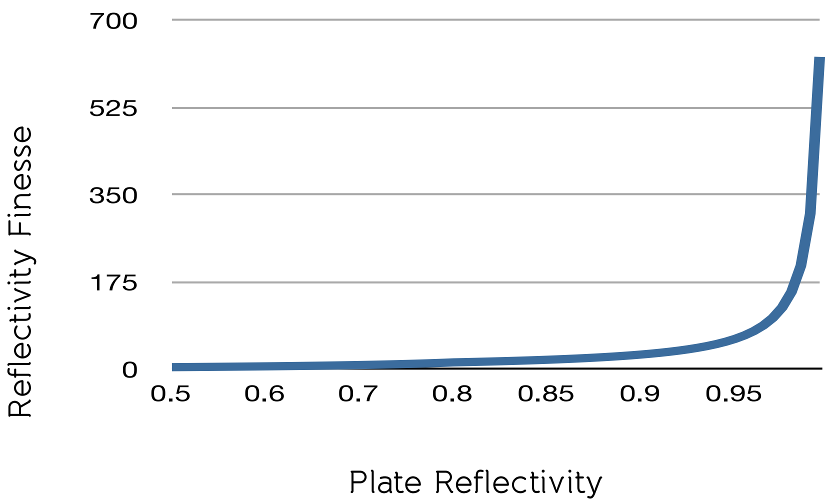

Figure TN2014-06b: Reflectivity finesse as a function of plate reflectivity

As with all equations in physics, this assumes a perfect situation. In reality the actual finesse will be lower than the reflectivity finesse $\mathcal{F}$ due to defects.

Defects can have a significant effect on the performance of an etalon and can be classified as follows:

-Spherical Defects
-Spherical Irregularities
-Parallelelism Defects

These will be described in more detail in a future technical note.

References:

Handbook of Optical Systems Volume 5, H. Gross (ed.), Wiley-VCH Verlag GmbH & Co KG, 2012, ISBN 978-3-527-40381-3

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