Frequency Calibration of the Series 100 and Series 200 SuperCavity™

Introduction

SuperCavity is a non-confocal, spherically symmetric Fabry Perot interferometer manufactured by Newport Corporation. This compact interferometer has an exceptional efficiency and an extremely high finesse across the specified bandwidth which allows it to be used for detailed investigations and analysis of coherent source mode structures in a near-real time environment.

SuperCavity is not constructed to allow for absolute frequency calibration. However, for many applications, relative calibration of the frequency of the source may be desirable. Before attempting the method of calibration to be described, the incoming beam from the source should be well-aligned and mode-matched to the fundamental cavity mode. (See the Newport Technical Application Note SR-001, "Mode-Matching to the SuperCavity").

A number of methods exist by which the frequency resolving power of Fabry-Perot interferometers such as SuperCavity can be calibrated. The calibration method of Fractional Mode Spacing (FMS) is the subject of this Technical Application Note. Please see the SuperCavity Manual and its references for the Theory of Operation and the theoretical discussion on Fabry-Perot interferometers.

Basic Equations

The cavity mode structure is composed of both longitudinal and transverse modes that are separated in frequency space (Fig. 1). The mode distribution is given by

$$f_{qmn} = \frac{c}{2L}\left[q + (m+n+1)\frac{\cos^{-1}\left(\pm\sqrt{g_1 g_2}\right)}{\pi}\right] \qquad (1)$$

where $c/2L$ = the longitudinal mode spacing,
c = the speed of light,
L = the cavity length,
m, n = transverse mode order = 0, ±1, ±2, ...,
q = longitudinal mode number,
g_i = $1 - L/R_i$, $i = 1, 2$
R_i = radius of curvature of the i^{th} mirror.

For the Newport SuperCavity, both the front and rear mirrors have radii of 300 mm. The nominal cavity length is either 25.4 millimeters or 20 microns. From Eq. (1) and for $g_1 = g_2 = g$, the longitudinal mode spacing is $c/2L$ and the transverse mode spacing is

$$\text{tranverse mode spacing} = \frac{c}{2L}\left(\frac{\cos^{-1} g}{\pi}\right) \qquad (2)$$

Eq. (2) may be approximated for R>>L by

$$\text{transverse mode spacing} = \frac{c}{\pi\sqrt{2LR}}$$

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The ratio of the transverse to the longitudinal mode spacing is referred to as the fractional mode splitting (FMS). The FMS values used to build standard Newport cavities are:

Type of Cavity	Fractional Mode Splitting
SR-100 Series (1")	0.131
SR 200 Series (20μm)	0.00365

With these values and Eq. (2), the length of the respective cavity may be found and used to calculate the longitudinal mode spacing:

Type of Cavity	Longitudinal Mode Splitting $\left(\frac{c}{2L}\right)$
SR-100 Series	5.984 ± 0.299 GHz
SR-200 Series	7601 ± 380 GHz

The inaccuracy in the above mode spacing is due to the corresponding inaccuracy in the cavity length. In absolute frequency space, the transverse mode splitting translates to the following:

Type of Cavity	Transverse Mode Splitting
SR-100 series	784 ± 40 MHz
SR-200 series	27.7 ± 1.4 GHz

The values above refer to the frequency difference between any two transverse modes, and may be used as a means for calibrating the observed spectra. This FMS may further be calibrated by injecting sidebands into the spectrum using an acousto-optic modulator as shown in the SuperCavity Instruction Manual.

For custom FSR SuperCavities, equations (1) and (2) may be used to calculate the FMS values using the appropriate cavity length (L).

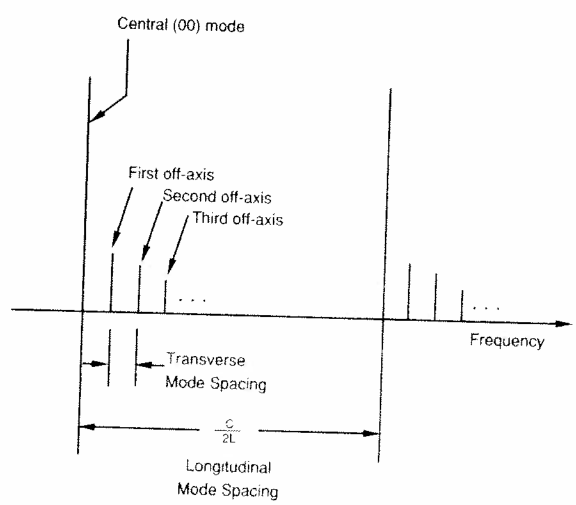

Fig. 1. SuperCavity mode structure and frequency space

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