which gives the following relation between the input and output intensities:

$$I_{\text{out}} = \frac{(1-R)^2 e^{-\alpha l}}{(1-Re^{-\alpha l})^2 + 4Re^{-\alpha l}\sin^2 kl} I_{\text{in}}. \tag{9.162}$$

Dispersive bistable optical devices

We first consider dispersive bistability in a Fabry–Perot cavity filled with a nonlinear medium that has an intensity-dependent index of refraction due to the optical Kerr effect. For simplicity, we ignore the standing wave pattern in the cavity and take the average intracavity intensity $I_c \approx I_f + I_b \approx 2I_{\text{out}}/(1-R)$. The intensity-dependent index of refraction is

$$n = n_0 + n_2 I_c \approx n_0 + \frac{2n_2 I_{\text{out}}}{1-R}. \tag{9.163}$$

Then, the total phase shift over a round trip in the cavity can be expressed as

$$2kl = \frac{2n_0\omega l}{c} + \frac{4n_2\omega l}{c(1-R)} I_{\text{out}} = 2m\pi + \varphi, \tag{9.164}$$

where m is a properly chosen integer such that

$$\varphi = \varphi_0 + \varphi_2 I_{\text{out}} \tag{9.165}$$

for $|\varphi_0| < \pi$ and

$$\varphi_2 = \frac{4n_2\omega l}{c(1-R)} = \frac{8\pi n_2 l}{\lambda(1-R)}. \tag{9.166}$$

Note that φ_0 is a bias phase that can be chosen at will by slightly varying the cavity length l for a given optical frequency ω or by varying the optical frequency for a fixed cavity length.

For the device under consideration, we can rearrange (9.162) as

$$\frac{I_{\text{out}}}{I_{\text{in}}} = \frac{F^2/F_0^2}{1 + 4(F^2/\pi^2)\sin^2(\varphi/2)}, \tag{9.167}$$

where

$$F = \frac{\pi\sqrt{Re^{-\alpha l}}}{1 - Re^{-\alpha l}} \tag{9.168}$$

is the *finesse* of a generic lossy Fabry–Perot cavity, and

$$F_0 = \frac{\pi\sqrt{R}}{1-R} \tag{9.169}$$

is the finesse of a lossless Fabry–Perot cavity. The characteristic described by (9.167) has resonance peaks at $\varphi = 0, \pm 2\pi, \pm 4\pi, \ldots$, each of which has the same characteristics as those of the peak shown in Fig. 9.27.