TEM$_{00}$thermo-insensitive cavity in the presence of several thermo-perturbing centers

Zhang Guangyin

(Department of Physics, Nankai University, Tianjin)

In complex lasers such as intracavity frequency-doubled, Q-switched, modelocked, several rods in series and so on, the cavity contains two or more thermal lenses caused by thermal effect. The equivalent focal distance of them have irregular fluctuating feature, so that they become thermo-perturbing centers within cavity. In the presence of several thermo-perturbing centers within the cavity, it is particularly necessary to find the thermo-insensitive configuration of cavity. Otherwise, that would be cause serious instability of the mode and power properties of laser output. However, up to now the researches on thermo-insensitive cavity deals only with that of single thermo-perturbing center. In this paper the general solution of TEM$_{00}$-thermo-insensitive cavity in the presence of several perturbing centers has been obtained by means of the transformation circle diagram[1]. That is if there are several thermo-perturbing lenses within cavity, the circles π in the places of thermo-perturbing centers are successively tangent each other, and the circle, σ_1 of one mirror R_1 of the cavity is tangent to one of the circle π_1, and the spot sizes of the fundamental mode in the places of thermo-perturbing centers determined by the circles π satisfy the requirement selecting fundamental mode by self-diaphram, such resonant cavity is the TEM$_{00}$-thermo-insensitive cavity.

In this article, in particular, frequency-doubled cavity as a typical example of TEM$_{00}$-thermo-insensitive cavity containing two thermo-perturbing centers has been analysed. According to the above mentioned general solution, the simple designing process of such cavity has been established, and its calculating formulas are as follows:

$$\phi=2\sqrt{\pi}\omega_2 \qquad (\phi\to\omega_2); \tag{1}$$

$$\omega_2=\sqrt{\frac{\lambda b_2}{\pi}} \qquad (\omega_2\to b_2); \tag{2}$$

$$\omega_1=\sqrt{\frac{\lambda b_1}{\pi}} \qquad (\omega_1\to b_1); \tag{3}$$

$$L_{12}=\sqrt{b_1 b_2} \qquad (b_1、b_2\to L_{12}); \tag{4}$$

$$\frac{1}{d_1}+\frac{1}{L_{12}}=\frac{1}{f_1} \qquad (L_{12}、f_1\to d_1); \tag{5}$$

$$L_1=\frac{b_1 d_1}{b_1+d_1} \qquad (b_1、d_1\to L_1); \tag{6}$$

$$R_1=\frac{2b_1 d_1^2}{d_1^2-b_1^2} \qquad (b_1、d_1\to R_1); \tag{7}$$

$$\frac{1}{d_2}+\frac{1}{L_{12}}=\frac{1}{f_2} \qquad (L_{12}、f_2\to d_2); \tag{8}$$

$$L_2=\frac{b_2d_2^2}{d_2^2+b_2^2} \qquad (b_2、d_2\to L_2)。 \tag{9}$$

It is easy to see, its calculation is very simple. A numerical example calculated by these formulas given as follows: $\phi=3.5$ mm, $\omega_2=1$ mm, $b_2=300$ cm, $\omega_1=0.1$ mm, $b_1=3$ cm, $L_{12}=30$ cm, $L_1=3.5$ mm, $R_1=6.1$ cm, $f_1=-100$ cm, $f_2=29.9$ cm, $L_2=10$ cm, $R_2=\infty$ ($\lambda=1.0\ \mu$).

The validity of the above analytical result can be proved from a lot of experimental work on frequency-doubled cavity [2,2].

The obtained general solution not only suit, design of TEM_{00}-thermo-insensitive frequency-doubled cavity, but also indicate the correct way to select TEM_{00}-thermo-insensitive cavity of any complex lasers.

References

[1] 张光寅,《激光》, No. 5,41 (1977).

[2] W. Culshaw, J. Kannelaud, J. E. Peterson, IEEE J. Quantum Electron., QE-10,253 (1974).

[3] J. D. Barry, Optics & Laser Technology, 9, 207 (1977).

存在多热扰中心情况下的基模热稳定

张光寅

（南开大学物理系）

在内腔倍频、Q开关、锁模、多棒串接等复杂激光器中，谐振腔内包含有两个或两个以上的由于热效应引起的热透镜。它们的等效焦距具有无规起伏的特点，如此它们成为腔内的一些热扰中心。在腔内存在多热扰中心情况下，特别需要寻求热稳腔结构。否则，这将导致激光输出的模式特性和功率特性的严重不稳定性。然而，迄今为止关于热稳腔的研究只停留在单热扰中心的情况。本文利用变换圆的图解法[1]获得了多热扰中心情况下的基模热稳腔的一般解。即是，若腔内有多少个热扰透镜，在这些热扰中心处的 π 圆相继相切，谐振腔的反射镜之一 R_1 镜的 σ_1 圆又和其中的 π_1 圆相切，而由各 π 圆决定的各热扰中心处的基模光斑尺寸又满足自孔径选基模的要求，这样的谐振腔就是多热扰情况下的基模热稳腔。

本文特别地分析了腔内包含有两个热扰中心的基模热稳腔的一个典型例子——倍频腔。根据上述一般解，我们确定了这种腔的简单设计方法与计算公式如下：

$$\phi=2\sqrt{\pi}\ \omega_2 \qquad (\phi\to\omega_2); \tag{1}$$

$$\omega_2=\sqrt{\frac{\lambda b_2}{\pi}} \qquad (\omega_2\to b_2); \tag{2}$$

$$\omega_1=\sqrt{\frac{\lambda b_2}{\pi}} \qquad (\omega_1\longrightarrow b_1); \tag{3}$$

$$L_{12}=\sqrt{b_1 b_2} \qquad (b_1、b_2\to L_{12}); \tag{4}$$

$$\frac{1}{d_1}+\frac{1}{L_{12}}=\frac{1}{f_1} \qquad (L_{12}、f_1\to d_1); \tag{5}$$

$$L_1=\frac{b_1 d_1}{b_1+d_1} \qquad (b_1、d_1\to L_1); \tag{6}$$

$$R_1=\frac{2b_1 d_1^2}{d_1^2-b_1^2} \qquad (b_1、d_1\to R_1); \tag{7}$$

$$\frac{1}{d_2}+\frac{1}{L_{12}}=\frac{1}{f_2} \qquad (L_{12}、f_2\to d_2); \tag{8}$$

$$L_2=\frac{b_2 d_2^2}{d_2^2+b_2^2} \qquad (b_2、d_2\to L_2)。 \tag{9}$$

容易看出，这种计算十分简单。下面给出按这些公式计算的一个数值例子：$\phi=3.5$mm（ϕ 为激光棒的直径），$\omega_2=1$mm，$b_2=300$cm，$\omega_1=0.1$mm，$b_1=3$cm，$L_{12}=30$cm，$L_1=3.5$mm，$R_1=6.1$cm，$f_1=-100$cm，$f_2=29.9$cm，$L_2=10$cm，$R_2=\infty(\lambda=1.0\mu)$。

上述分析结果的正确性可以从一些倍频腔的实验工作中[2, 3]找到证明。

获得的一般解不仅适用于基模热稳倍频腔的设计，而且为任何复杂激光器的基模热稳腔的选择指明了正确的路子。