Zeeman effect and mode competition effect in two-frequency laser

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Two-frequency laser has wide uses in new laser interferometer. The study of Zeeman effect and mode competition effect for that laser is much important in practice as well as in theory, but it has not been reported up to now. In this paper, we have studied these problems both theoretically and experimentally. At first, we have calculated the anomalous Zeeman splitting of Ne atom. The results show that, Lande g-factors are

$$g_J=\frac{(g_K+2)\,J(J+1)+(g_K-2)K(K+1)-(g_K-2)\,S(S+1)}{2J(J+1)}$$

$$g_K=\frac{(g_{J_c}+1)K(K+1)(g_{J_c}-1)J_C(J_C+1)-(g_{J_c}-1)l(l+1)}{2K(K+1)}$$

$$g_{J_c}=1+\frac{J_C(J_C+1)+S_C(S+1)-L_C(L_C+1)}{2J_C(J_C+1)}$$

where J, K, S, J_C, l, S_C, L_C are corresponding angular momentum quantum number in Racah model. The left — and right handed circular polarized light produced by Zeeman splitting individually consist of three spectral lines, whose strength is not the same. Their frequency displacements are:

$$\Delta\nu=\pm\frac{4}{3},\ \pm\frac{7}{6},\pm 1\ \cdot\left(\frac{\mu_B}{h}\cdot H\right)$$

where μ_B is Bohr magneton, h is Planck constant, H is magnetic field, "+" and "−" show two circular polarization separately.

Calculating results also show that, Zeeman splitting will influence upon Lamb dip in left-and right — handed light: when mode competition is not considered, Lamb dip still appear for uniform magnetic field whose strength is lower than 500 Gausses; Lamb dip will not appear for nonuniform magnet (e.g. permanent magnet).

Moreover, we have studied the mode competition with Lamb's theory of the polymode laser. The results show that, in two-frequency laser, when magentic field stregnth is lower than 350 Gausses and the frequency separation of the longitudinal modes is $\Delta\nu=$ 1000 MH_Z, Lamb dip in left — and right handed circular polarized light can appear only in a few special conditions, that is, magnetic field strength is lower than 70 Gausses and is equal to 310 Gausses. While the "magnetic dip", which is produced by mode competition, will appear in most conditions. The magnetic dip makes power tuning curve form two peaks which are not symmetric and are different in magnitude and shape for different magnetic field strength when the frequency separation of the longitudinal modes is kept constant.

We have made experiments with the magnetic field strength from O to 350 Gausses. The results of experiment are in accordance with our theortical analysis.

双频激光器中的塞曼效应和模竞争效应

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双频激光器在新型激光干涉仪中有重要用途。塞曼效应和模竞争效应对双频激光器的输出特性和稳频特性有很大影响。然而对这个问题的研究迄今未见报导。本文对此从理论上和实验上作了研究。首先，我们计算了 Ne 原子的反常塞曼分裂。计算结果给出：朗德因子

$$g_J=\frac{(g_K+2)J(J+1)+(g_K-2)K(K+1)-(g_K-2)S(S+1)}{2J(J+1)}$$

$$g_K=\frac{(g_{Jc}+1)K(K+1)+(g_{Jc}-1)J_c(J_c+1)-(g_{Jc}-1)l(l+1)}{2K(K+1)}$$

$$g_{Jc}=1+\frac{J_c(J_c+1)+S_c(S_c+1)-L_c(L_c+1)}{2J_c(J_c+1)}$$

其中 J、K、S、T_c、J、S_c、L_c 分别是拉卡矢量模型中的各个角动量的量子数。塞曼分裂产生的左旋光与右旋光各由三条强度不等的谱线组成。它们的频移是：

$$\Delta\nu=\pm\frac{4}{3},\ \pm\frac{7}{6},\pm 1\cdot\left(\frac{\mu_\beta}{h}\cdot H\right)$$

其中 μ_β 是玻尔磁子，h 是普朗克常数，H是磁场、“+”“−”分别表示两种圆偏振。

计算结果还表明：塞曼分裂将对拉姆下陷有影响：在不考虑模竞争情况下，对于小于500高斯的均匀磁场将产生拉姆下陷；对于非均匀磁场(如永久磁铁)将不产生拉姆下陷。

进而，我们利用拉姆的多模激光理论研究了模竞争效应。结果表明：在双频激光器中当磁场小于 350 高斯并且纵模间距 $\Delta\nu$=1000MHz 时，左旋光与右旋光的拉姆下陷仅在很少情况下，即当磁场小于 70 高斯和等于 310 高斯时才出现；而在多数情况下将出现所谓“磁下陷”，磁下陷是模竞争产生的。它使功率调谐曲线形成不对称的双峰。当纵模间距不变时，双峰大小和形状随磁场强度而变化。我们用 0～350 高斯的均匀磁场做了实验。实验结果与理论分析符合较好。