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**On laser theories**

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The laser (light amplification by stimulated emission of radiation) consists, ideally, of a macroscopic sample of polarizable matter with two energy levels interacting with its own polarization field and an external electromagnetic field. It is envisaged, generally, that the external field may couple to the two energy levels, by excitation and disexcitation processes, achieve a macroscopic occupation of the upper level, which may be discharged (stimulated emission) as a coherent (same phase) radiation (amplification). A similar mechanism is supposed to act for the maser (microwave amplification etc), as well as for many other types of similar devices. However, in practical instances, a population inversion is realized at the beginning, which is thereafter discharged by an external field. In this case, the lasing energy has only a small contribution from the feeding external field. Consequently, the current laser theories[1] [1]-[4] which focus on this practical realization of the laser effect have nothing to do with the conceptual mechanism of interaction, supposed to act in lasers.

These curent laser theories start with Maxwell's equations for external and total fields, the latter including the internal fields, like polarization field and magnetization. The polarization becomes easily the source for the total field, by such equations. Actually and rigorously, the polarization is source for the polarization, internal field only, and the external field can be added to such an equation for the internal field only by assuming that it obeys the wave equation with its own, unmodified frequency. But this is an unwarranted supposition, because, one may expect that the frequency of the external field is modified (as that of the internal field is) by the presence of the matter sample, as the latter is modified (polarized) by the presence of the external field. Indeed, actually, this is the real situation.[5, 6] Maxwell's equations for matter are classical equations, and, classically, the polarization is indeed related directly to the polarization field. Bringing into discussion the two enegy levels however, the polarization gets a quantum aspect, and it is in fact a bilinear form in the amplitudes of occupation of the two levels; which, in turn, obey Schrodinger's equations with interaction arising from the total field. These three coupled equations are nonlinear, and this makes the frequency to be changed.

Assuming an unchanged frequency for the external field, a similar assumption comes easily also for the polarization (internal) field as well as for the polarization.[1]-[4] This assumption is equally unwarranted. It is easy to recognize however here the basic assumptions for the time-dependent perturbation theory in computing the excitation and disexcitation rates; which these theories more or less tacitly assume. It is no surprise in this context that these theories deal mainly with the transient, time-dependent states.

The above assumptions of the laser theories bring immediately an undesirable feature, that of higher frequency contributions to the equations of motion for the occupancy amplitudes (through

[1] The source is Ref. [1]

non-linear terms). The situation is similar, to some extent, with the anharmonic terms for the harmonic oscillator, where it is known that, beside special resonances, the frequency changes. The current laser theories diregard such terms, by the "rotating wave approximation" (!) (the higher frequencies are simply declared as not being troublesome!), which again is an unwarranted procedure. The solution obtained thereby is wrong. And it has, moreover, no connection with the mechanism of the real lasers.

The main "result" of such a "solution" is the necessary condition of a population inversion, *i.e.* the upper level should be more occupied than the lower level in order to get the laser effect; if not, there is no such effect. The corect solution however,[5, 6] shows that this is not a necessary condition. Besides, the population inversion for a lasing effect requires no theory.

# References

[1] W. E. Lamb, Phys. Rev. **134** A1429 (1964).

[2] M. Sargent, M. O. Scully and W. E. Lamb, *Laser Physics*, Addison-Wesley, Reading (1974).

[3] W. H. Louisell, *Quantum Statistical Properties of Radiation*, Wiley, NY (1973).

[4] H. Haken, *Laser Theory*, in *Encyclopedia of Physics*, vol. XXV/2c, S. Flugge ed., Springer, Berlin (1970).

[5] M. Apostol, Phys. Lett. **A373** 379 (2009).

[6] M Apostol and M. Ganciu, J. Theor. Phys. **188**, **189** (2010).