Features of resonant absorption and X-Ray (gamma-Ray) laser amplification in realistic (inhomogeneous) media

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Abstracts: *In the work the problem of influence of space distribution of electron, atoms and molecules in any realistic material target on effective susceptibility and permittivity and on the threshold conditions for short-wave laser generation is discussed.*

The influence of microstructure of material medium (including features the spatial distribution of electrons, atoms or molecules) on its effective electromagnetic characteristics (susceptibility, sensitivity and permittivity) are discussed and investigated. Such influence previously has been considered only for short-wave diffraction effects and it was not taken into account during the propagation and interaction of electromagnetic waves in realistic medium [1]. The wave equation, which takes into account this influence, and some of its solutions are found.

It is shown for the first time that the features of the propagation of electromagnetic waves depend not only on the average values of these parameters (sensitivity and permittivity), but also on their spatial distribution on nanolevel. This effect is of great importance in the X-ray and gamma-Ray region but is not essential for microwave, visual and ultraviolet regions and don't change previously well known optical laws! It is shown that the presence of these features leads to a strong mutual influence of the real and imaginary parts of the susceptibility in realistic linear mediums. It was shown also that coefficient of resonant X-Ray and gamma-Ray amplification for realistic (atomic inhomogeneous) medium

$$G_{realistic} = \frac{\omega}{c}\bar{\chi}_n''(\omega)\{1-2(\bar{\chi}_n'(\omega)+\bar{\chi}_e'(\omega))K_3\} \approx$$
$$\frac{<\Delta n_n^{(2\leftrightarrow 1)}(\boldsymbol{r})>\sigma_0\Gamma^2}{(\omega_0-\omega)^2+\Gamma^2}\left\{1+\left(4\frac{<n_n(\boldsymbol{r})>c\sigma_0(\omega-\omega_0)}{\omega_0\Gamma\{1+[2(\omega_0-\omega)/\Gamma]^2\}}+2\frac{\omega_p^2}{\omega^2}\right)K_3\right\}, K_3>>1$$

differs significantly from the similar coefficients for homogeneous medium

$$G_{homog} = \frac{<\Delta n_n^{(2\leftrightarrow 1)}(\boldsymbol{r})>\sigma_0\Gamma^2}{(\omega_0-\omega)^2+\Gamma^2}$$

Applied aspects of these results to optimize the problem of creating X-Ray and gamma-Ray laser are discussed.

1. Vysotskii V.I., Vysotskyy M.V. *Journal of Surface Investigation. X-ray, Synchrotron and Neutron Techniques #* **7**, 51 (2013).
2. Vysotskii V.I., Kuz'min R.N. Gamma-Ray Lasers. (Moscow, Moscow State Univ. Publ. House, 1989).