Numerical Calculation of Gain Coefficients of Recombination X-Ray Laser in a Cluster Plasma

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Abstracts: *For realization of the plasma X-ray laser due to charge exchange recombination process, we examined the optimal plasma condition by numerical calculation. The lasing medium is cluster plasma, where C_{60} cluster in the helium gas is irradiated with ultrashort, intense laser pulses. In this study, we focused on the charge transfer process of C^{6+} + He →C^{5+}(n=3) + He^{+}, whose cross section is ~10^{15} cm^2.As a result, it is found that the large gain coefficient is obtained in a specific plasma condition.*

It is expected that the soft x-ray lasers provide an innovative research method in various scientific and engineering fields, such as, solid state physics, material engineering and biomedical science. As one of the generation method of plasma x-ray laser, the recombination scheme has an advantage, because the input energy required to create the laser medium is lower than that of the transient electron excitation scheme. In addition, charge-exchange recombination process could contribute to the efficient population inversion. In this study, we performed numerical study to optimize plasma parameters for lasing of the recombination soft x-ray laser in hydrogen-like carbon (C^{5+} *n*=2-3 transition: 18.2 nm). Here, the lasing medium is a cluster plasma, which is generated by irradiating with a femtosecond laser pulse onto a mixture of C_{60} clusters and helium gas. Note that the cluster efficiently absorbs the laser energy due to collisional heating in solid density, while the He is still neutral. As a result, the cluster plasma is subjected to charge exchange recombination with the He atom, C^{6+} + He →C^{5+}(*n*=3) +He^{+}. The cross section is around ~10^{15} cm^2 at low collision energies. The population densities of C^{6+} ion and C^{5+} levels are derived by solving the coupled rate equations, in which the effect of the charge-exchange process is incorporated. As for the optical thickness of the transition from *n*=1 to *n*=2 of C^{5+} ion, the radiative transfer equation is solved. The gain coefficient in the cluster plasma is calculated for various plasma conditions. In the presentation, details of the numerical results will be discussed.