Laser polarization effect on nitrogen fluorescence emission induced by femtosecond filament in air

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Synopsis The laser polarization effect on nitrogen fluorescence emission induced by femtosecond filament in air is studied. By comparing the femtosecond filament induced fluorescence emission under different pump laser polarizations in different focal length cases, the emission mechanism of nitrogen fluorescence induced by femtosecond filament is discussed.

During the femtosecond laser filamentation in air, the intensity inside the filament stays around $10^{13} \sim 10^{14}\mathrm{W/cm^2}$ due to the dynamic balance between Kerr self-focusing and plasma defocusing effect [1, 2], which is intense enough to excite, ionize or dissociate the molecules in air, generating a large number of excited molecules and molecular ions. These molecules and molecular ions undergo complicated transition process, emitting characteristic fluorescence [3, 4, 5]. Femtosecond filament induced fluorescence has been has been used to characterize the filamentation process [6], extract the electron temperature and laser intensity inside filaments, and explore the interaction processes between femtosecond laser and atoms and molecules[3, 4, 7]. In addition, the high sensitivity, non-intrusiveness, and real-time analysis of femtosecond laser-induced fluorescence in the field of remote sensing of atmospheric trace species arouses our enthusiasm in the study of it.

In air, the femtosecond filament induced fluorescence mainly comes from nitrogen. However,the emission mechanism of nitrogen fluorescence is still controversial, especially that of the fluorescence from N_2 (e.g., 337-nm line). Since the transition between the singlet state and triplet state of N_2 is spin forbidden, $N_2(C^3\Pi_u^+)$ can not be formed due to the direct high-field photonic excitation.

In this work, the influence of laser polarization state on nitrogen fluorescence emission induced by femtosecond filament in air is investigated as the focal length of focusing lens is different. Fig. 2 shows the backward fluorescence spectra induced by the linearly and circularly polarized pulses. It can be clearly seen from the figure that there exists difference between the emission behaviors of N_2 and N_2^+ fluorescence under different laser polarizations: for fluorescence from N_2 (e.g. 337, 357, 380 and 406 nm lines *etc.*), it is more intense in the circular polarization case, while for that from N_2^+ (391 and 428 nm lines), its intensity is higher in the linear polarization case. Based on the observation, the emission mechanism of nitrogen fluorescence induced by femtosecond filament is discussed.

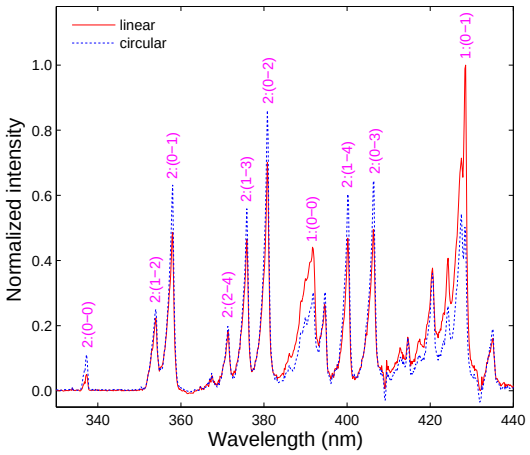

Figure 1. Backward fluorescence spectra induced by the linearly and circularly polarized pulses as the input pulse energy is 1.6 mJ. The focal length is $f = 25$ cm. In the transitions $v - v'$, v and v' denote the vibrational levels of upper and lower electronic states, respectively.

References

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