Dependence of Population Transfer in N_2^+ on the Ionization Timing in a Strong Laser Field

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In the past few decades, the coherent and unidirectional radiation called air-lasing generated when intense femtosecond laser pulses are focused in air has been investigated intensively, and special attention has been paid to the air lasing at 391 nm corresponding to the emission from the vibrational ground state of the B state, B(*v*' = 0), of N_2^+ to the vibrational ground state of the X state, X(*v*" = 0), both experimentally and theoretically.[1] We have revealed in a series of studies[1–3] that a sudden turn-on model explains well the efficient post-ionization excitation process leading to population inversion between the B state and the X state in N_2^+.[1,2,3]

Rotational coherence during the population transitions in N_2^+, has been demonstrated by including the electronic, vibrational, and rotational degrees of freedom in the sudden turn-on model.[4,5] However, all previous work focusing on the ionization which happens in the center of the laser pulse leaves the ionization timing dependence to be clarified.

In this work, based on the complete theoretical model including the electronic, vibrational, and rotational degrees of freedom,[4] we have further developed a simulator to examine the dependence of the population transfer process in N_2^+ on the ionization timing within an intense laser pulse. We have compared the population transfer and the final distribution of the populations in the B(*v*' = 0) and X(*v*" = 0) states of N_2^+, which are generated at different times before and after the center of the ultrashort laser pulse.

We have revealed that the population difference between the B(*v*' = 0) and X(*v*" = 0) states exhibits characteristic dependence on the ionization timing, similar to the oscillation of the electric field of the laser pulse. Though the extent of the vibrational population difference in N_2^+ generated a half cycle before the center of the laser pulse and that generated at the center are almost the same, the rotational population differences, reflected to the intensities in the R-branch and P-branch emission lines, exhibit a marked difference, indicating that the rovibronic population transfer sensitively depends on the ionization timing.

References:

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