Rotational coherence created in the B state of N_2^+ in air lasing at 391 nm

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When intense femtosecond laser pulses are focused in air, coherent and unidirectional radiation at 391 nm called air-lasing is generated, corresponding to the emission from the B state of N_2^+ to the X state.[1,2] It was revealed recently by strong field Fourier transform spectroscopy that the A-X coupling in N_2^+ plays a crucial role in creating the population inversion between the B and X states,[3] resulting in the air-lasing. In this work, we investigate the rotational coherence created in the air-lasing by a pump-probe experiment and examine the mechanism of the population transfer induced by the post-ionization excitation in an intense laser field by adopting our theoretical model[4] in which the rotational degrees of freedom are explicitly included.

We simulate the experimental B-X emission spectrum recorded as a function of the pump-probe time delay by taking account of the population difference between B (v = 0) state and X (v = 0) state. The characteristic temporal evolutions of the intensity profiles appearing in the experimental spectrum are reproduced well. The appearance of the two R branch profiles can be ascribed to the rotational coherence in the B (v = 0) state prepared by the pump and probe pulses, reflecting the difference in the rotational selection rules of the A-X and B-X transitions as well as the difference in their transition intensities.

1) H. Xu, E. Lötstedt, A. Iwasaki, K. Yamanouchi, *Nat. Commun*. **6**, 8347 (2015). 2) Y. Zhang, E. Lötstedt, and K. Yamanouchi, *J. Phys. B: At. Mol. Opt. Phys.* **52**, 055401 (2019). 3) T. Ando, E. Lötstedt, A. Iwasaki, H. Li, Y. Fu, S. Wang, H. Xu, and K. Yamanouchi, *Phys. Rev. Lett.* **123**, 203201 (2019). 4) Y. Zhang, E. Lötstedt, and K. Yamanouchi, *Phys. Rev. A* **101**, 053412 (2020).

