Development of a plasma shutter applicable to 100-mJ-class, 10-ns laser pulses and the characterization of the residual field intensity

Je Hoi Mun[1,2], Shinichirou Minemoto[1], and ○Hirofumi Sakai[1,3]

[1]Department of Physics, Graduate School of Science, The University of Tokyo

[2]Center for Relativistic Laser Science, Institute for Basic Science (IBS)

[3]Institute for Photon Science and Technology, Graduate School of Science, The University of Tokyo

E-mail: hsakai@phys.s.u-tokyo.ac.jp

Techniques for manipulating rotational motion of molecules have progressed a lot during the last quarter century since the theoretical proposals both in the adiabatic [1] and in the nonadiabatic [2] regimes. In order to prepare a strongly oriented molecular ensemble, the adiabatic control of the rotational dynamics of molecules is of crucial importance [3-5]. However, in the adiabatic regime, the molecular orientation is achieved only in the presence of intense laser fields. To exploit the advantage of the adiabatic orientation and to achieve higher degrees of orientation in the field-free condition, a plasma shutter technique has been employed to rapidly turn off the laser pulse with a slow turn on, so that the adiabatic orientation achieved in the presence of intense laser fields can be transferred to the laser-field-free condition [6]. The pulse shaping technique based on the plasma shutter can become a useful tool also for preparing ultracold molecules via photoassociation [7,8].

On the other hand, researchers are very much interested in the residual laser field intensity in the laser-molecule interaction region after the rapid turn off [9], which has not been quantitatively characterized so far. In this work, we experimentally and numerically demonstrate that the residual field intensity is actually negligible [10]. Figure 1 shows our experimental setup for generating and characterizing the shaped two-color laser pulses.

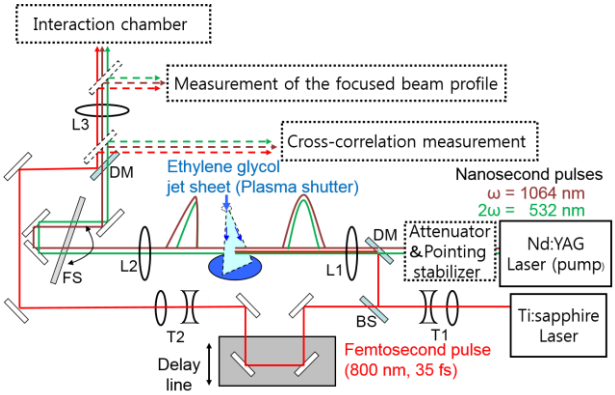

Fig. 1. A schematic diagram of the experimental setup (taken from Ref. [10]). L1, L2, L3: lens, T1, T2: telescope for beam collimation. DM: dichroic mirror. BS: beam splitter. FS: fused silica.

[1] B. Friedrich and D. Herschbach, Phys. Rev. Lett. **74**, 4623 (2005).
[2] T. Seideman, Phys. Rev. Lett. **83**, 4971 (1999).
[3] Y. Sugawara, A. Goban, S. Minemoto, and H. Sakai, Phys. Rev. A **77**, 031403(R) (2008).
[4] M. Muramatsu, M. Hita, S. Minemoto, and H. Sakai, Phys. Rev. A **79**, 011403(R) (2009).
[5] J. H. Mun and H. Sakai, Phys. Rev. A **98**, 013404 (2018).
[6] A. Goban, S. Minemoto, and H. Sakai, Phys. Rev. Lett. **101**, 013001 (2008).
[7] W. Zhang, Y. Huang, T. Xie, G.-R. Wang, and S.-L. Cong, Phys. Rev. A **82**, 063411 (2010).
[8] Y.-C. Han, J.-W. Hu, and B.-B. Wang, Phys. Rev. A **98**, 043420 (2018).
[9] A. S. Chatterley, E. T. Karamatskos, C. Schouder, L. Christiansen, A. V. Jørgensen, T. Mullins, J. Küpper, and H. Stapelfeldt, J. Chem. Phys. **148**, 221105 (2018).
[10] J. H. Mun, S. Minemoto, and H. Sakai, Opt. Express **27**, 19130 (2019).