# Simulations of strong laser-driven multielectron dynamics using classical and quantum computers

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High-field physics and attosecond science are rapidly progressing towards world-changing goal of direct measurement and control of the electron motion in matters. To theoretically investigate intense laser-driven multielectron dynamics, the multiconfiguration time-dependent Hartree-Fock method [1-3] has been developed, which, though powerful, suffers from exponential increase of the computational cost with respect to the number of electrons.

To overcome this difficulty, more cost-effective time-dependent multiconfiguration methods have been developed [4-7], which substantially extend the applicability of accurate multielectron simulations. Furthermore, we have succeeded in formulating time-dependent coupled-cluster method using time-dependent orbitals, called TD-OCC method [8,9], which realizes gauge-invariant and size-extensive description of multielectron dynamics.

In this talk, I will summarize theory and implementation of these simulation methods [10-13], both on classical and quantum computers. The efficient implementation enables *ab initio* description, beyond single-active-electron approximation or time-dependent density functional theory, of high-field phenomena directly relevant to experiments, e.g., nonsequential double ionization of noble gas atoms, high-harmonic generation (HHG) enhanced by laser-induced electron recollision [14, 15], and laser polarization-dependent multichannel and multielectron effects on HHG from molecules.

1) J. Zanghellini, M. Kitzler, C. Fabian, T. Brabec, and A. Scrinzi, Laser Phys. 13, 1064 (2003). 2) T. Kato and H. Kono, Chem. Phys. Lett. 392, 533 (2004). 3) J. Caillat, J. Zanghellini, M. Kitzler, O. Koch, W. Kreuzer, and A. Scrinzi, Phys. Rev. A 71, 012712 (2005). 4) T. Sato and K. L. Ishikawa, Phys. Rev. A 88, 023402 (2013). 5) H. Miyagi and L. B. Madsen, Phys. Rev. A 89, 063416 (2014). 6) D. J. Haxton and C. W. McCurdy, Phys. Rev. A 91, 012509 (2015). 7) T. Sato and K. L. Ishikawa, Phys. Rev. A 91, 023417 (2015). 8) T. Sato, H. Pathak, Y. Orimo, and K. L. Ishikawa, J. Chem. Phys. 148 051101 (2018). 9) H. Pathak, T. Sato, and K. L. Ishikawa, J. Chem. Phys. 152 124115 (2020).
10) R. Sawada, T. Sato, and K. L. Ishikawa, Phys. Rev. A 93, 023434 (2016). 11) T. Sato, K. L. Ishikawa, I. Březinová, F. Lackner, S. Nagele, and J. Burgdörfer, Phys. Rev. A 94, 023405 (2016). 12) Y. Orimo, T. Sato, A. Scrinzi, and K. L. Ishikawa, Phys. Rev. A 97, 023423 (2018). 13) Y. Orimo, T. Sato, A. Scrinzi, and K. L. Ishikawa, Phys. Rev. A 100, 013419 (2019). 14) Y. Li, T. Sato, and K. L. Ishikawa, Phys. Rev. A 99, 043401 (2019). 15) I. S. Wahyutama, T. Sato, and K. L. Ishikawa, Phys. Rev. A 99, 063420 (2019).