Supplementary Information

A tug-of-war between electronic excitation and confinement in a dynamical context

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**Fig. S1.** Time evolution of chemical potential (µ, in a.u.) when helium atom in ground state (G.S.) and excited state (E.S.) is placed in intense laser field. (Amplitude = 0.01 a.u.). Black line represents unconfined system and red line represents confined system. Weizsäcker and Fermi-Amaldi functionals are used in these cases.
**Fig. S2.** Time evolution of chemical hardness (\( \eta \), in a.u.) when helium atom in ground state (G.S.) and excited state (E.S.) is placed in intense laser field. (Amplitude = 0.01 a.u.). Black line represents unconfined system and red line represents confined system.

**Fig. S3.** Time evolution of polarizability (\( \alpha \), in a.u.) when helium atom in ground state (G.S.) and excited state (E.S.) is placed in intense laser field. (Amplitude = 0.01 a.u.). Black line represents unconfined system and red line represents confined system.
Fig. S4. Time evolution of hardness ($\eta$, in a.u.) and polarizability ($\alpha$, in a.u.) during a collision process between a proton and helium atom in ground state and excited state. Black line represents unconfined system and red line represents confined system.