

## Accepted Manuscript

Title: Chemical Analysis: Double Core-Hole Spectroscopy with Free-Electron Lasers

Author: N. Berrah L. Fang

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**Highlights of manuscript entitled “Chemical Analysis: Double Core-Hole Spectroscopy with Free-Electron Lasers by Berrah & Fang**

- Free-electron lasers have enabled chemical analysis of similar molecules due to their femtosecond pulse duration, high pulse energy and tunable photon energy in the -x-ray regime
- We have exploited the attributes of these new lasers by exploring intriguing non-linear effects such as double core-hole formation.
- Multiphoton absorption is key to the observation of double core-holes in atoms and molecules .
- We have carried out x-ray two-photon photoelectron spectroscopy for molecular chemical analysis using the Linac Coherent Light Source.
- Our experimental work validated the theory of two-photon photoelectron spectroscopy.
- This work demonstrates that our methodology will be very effective with the future intense, high repetition rate as well as laser-seeded or self-seeded photon facilities.

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