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Novel Measurements Enabled by a CW Source

Joel D. Brock
School of Applied & Engineering Physics
Cornell High Energy Synchrotron Source (CHESS)
Cornell University

Intensity Fluctuation Spectroscopy

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Ultra-fast pulses at high repetition rate enable fluorescence (confocal) microscopy with hard x-rays.

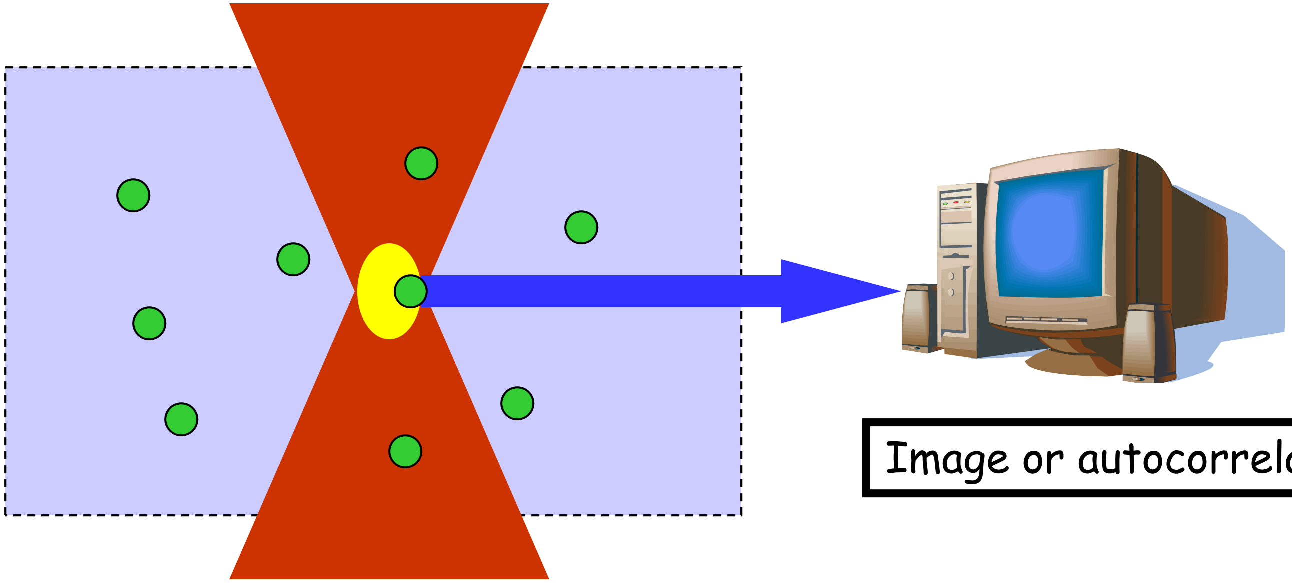

Image or autocorrelate

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Boost Signal with Multi-photon Ionization of core levels

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Fluorescence rate is given by

$$\boxed{\langle F(t)\rangle = \frac{1}{2} g^{(2)} \phi \eta c \sigma_{1s}{}^{(2)} \langle I_o(t)\rangle^2 \int d\vec{r}\, S^2(\vec{r}) \quad \rightarrow \quad c\sigma_{1s}{}^{(2)}\, \Phi^2}$$

- $g^{(2)}$ is the degree of 2nd-order coherence,
- η is the collection efficiency of the detector,
- φ is the quantum efficiency of the atom,
- c is the concentration of the atom,
- $I_o(t)$ is the intensity of the pulse,
- $S(r)$ is the shape of the pulse.

Resonant absorption cross sections

(these cross sections are controversial)

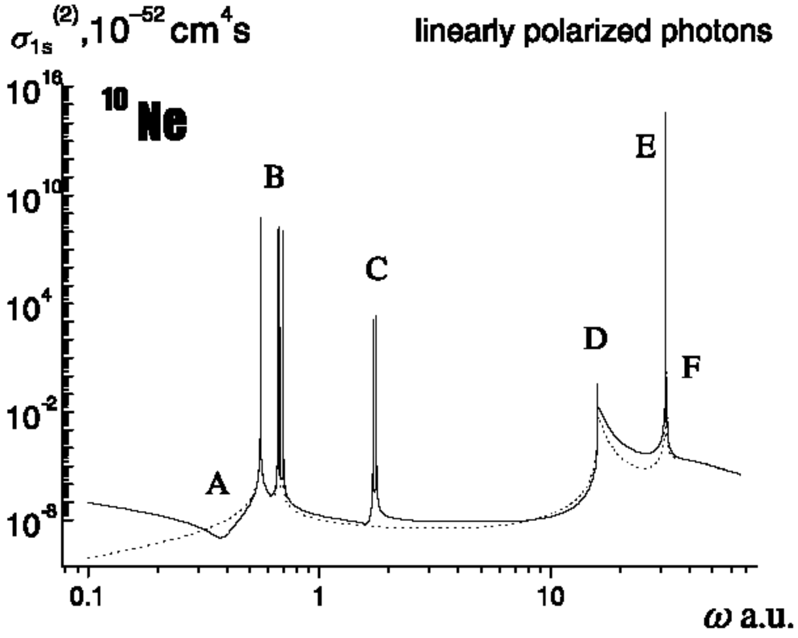


Figure 1. The cross section $\sigma_{1s}^{(2)}$ of the process of excitation/ionization of the Ne 1s shell by two linearly polarized photons calculated taking into account the effect of relaxation of the atomic residue in the field of the creating vacancies with (full curve) and without accounting for this effect (dotted curve). See the text for notation A, B, C, etc. Hereafter the photon energy ω is presented in atomic units.

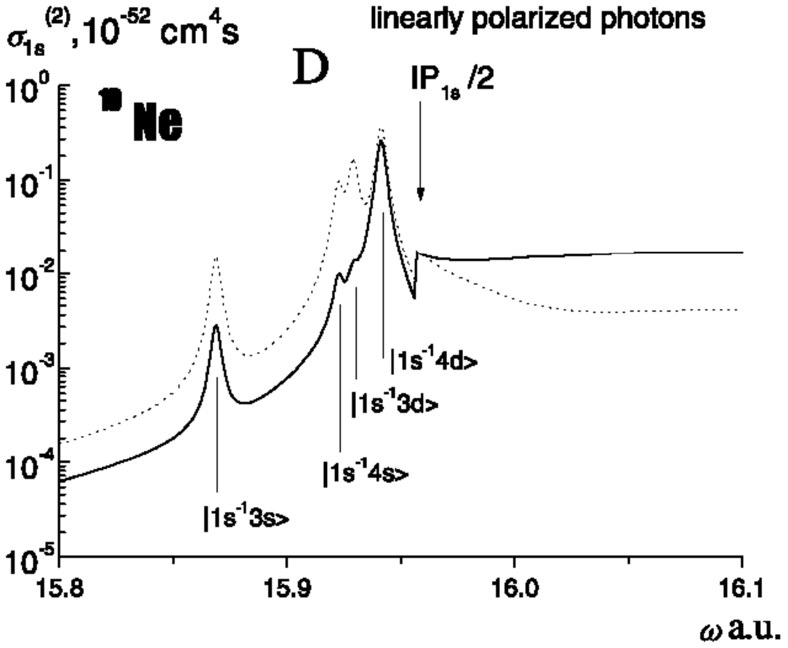


Figure 3. The cross section $\sigma_{1s}^{(2)}$ (region D) of the process of excitation/ionization of the Ne 1s shell by two linearly polarized photons calculated taking into account the effects of relaxation of the atomic residue in the field of the creating vacancies with (full curve) and without accounting for this effect (dotted curve). In the figure the discrete final states are indicated.

S.A. Novikov and A.N. Hopersky, *Two-photon excitation/ionization of atomic inner shells.* Journal of Physics B-Atomic Molecular and Optical Physics, 2000. **33**(12): p. 2287-94.

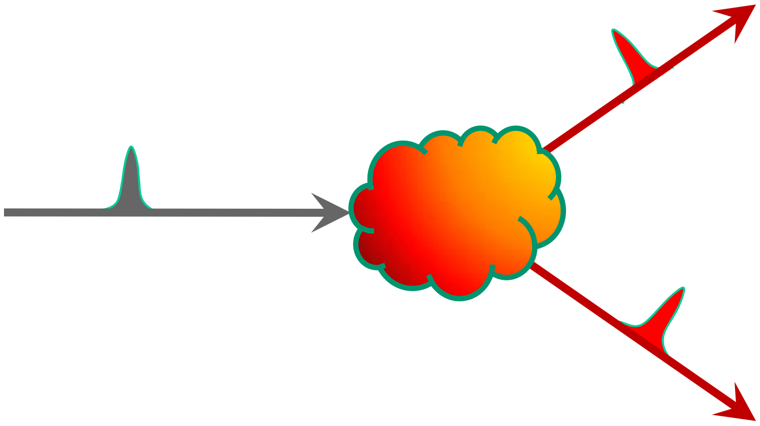
Multi-photon ionization with lasers strips off valence electrons. In contrast, multi-photon ionization with x-rays strips off core electrons. The resulting phenomena are quite rich (photo, Auger, 2-photon/2-electron, sequential, and correlated ionization).

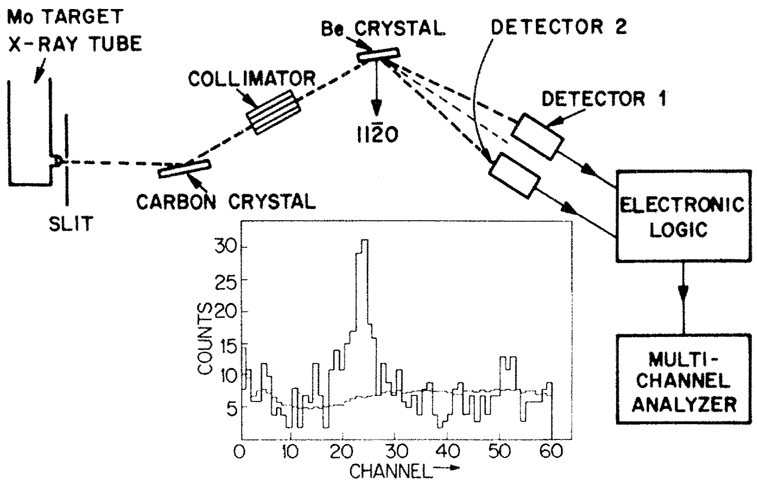
Suggestion is to use particle-particle (i.e., electron-electron) coincidence measurements to find the “needle in the haystack.”

Key Point: The high repetition rate makes these experiments do-able due to the **true-to-false ratio for coincidence measurements:**

Coincidence Measurements

Example: parametric down conversion





$$\frac{T}{F} = \frac{\eta_t C f}{\left(\eta_1 C + N_1\right)\left(\eta_2 C + N_2\right)}$$

$\eta_{t,1,2}(\sigma,\theta,\varepsilon) \equiv$ detection coefficients

$N_{1,2} \equiv$ noise counts

$C \equiv$ average count rate

$f \equiv$ repetition rate

Eisenberger, P. and S.L. McCall, *Physical Review Letters, 1971.* **26**(12): p. 684-688.