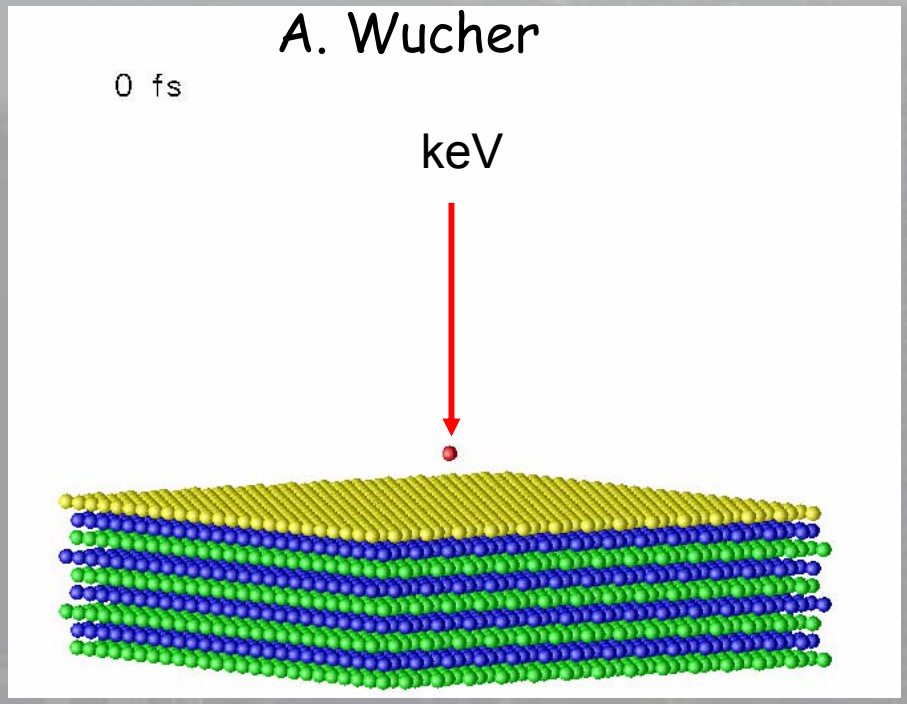
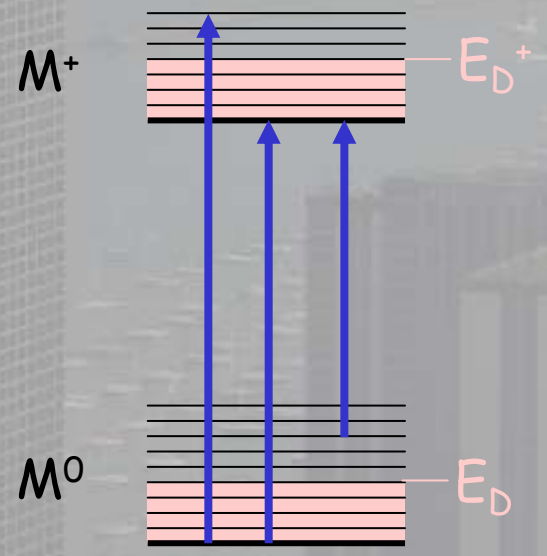
Single Photon Ionization for Materials Characterization



single photon ionization

molecular species

- above-threshold ionization
- threshold ionization
- **sub-threshold** ionization



$h\nu$ > IP : heating of molecule

$h\nu$ ~ IP : soft ionization

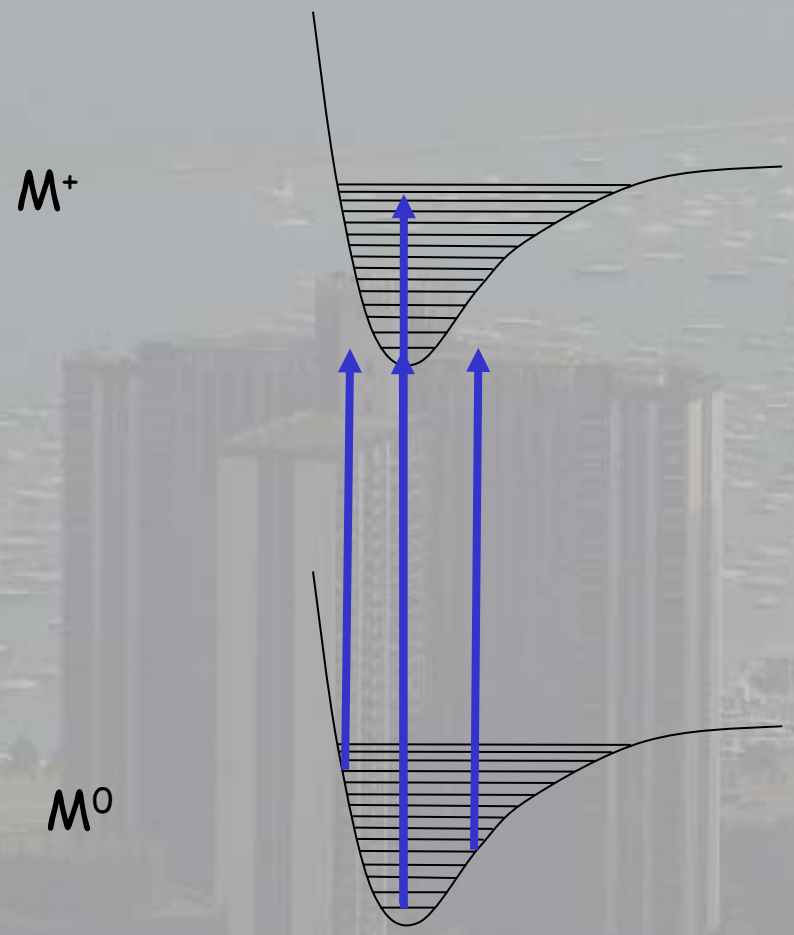
$h\nu$ < IP : cooling of molecule

- essential quantity:

  Franck-Condon factors
  for vibrational transitions

single photon ionization

Franck-Condon transitions



strong geometry change upon ionization

no geometry change upon ionization

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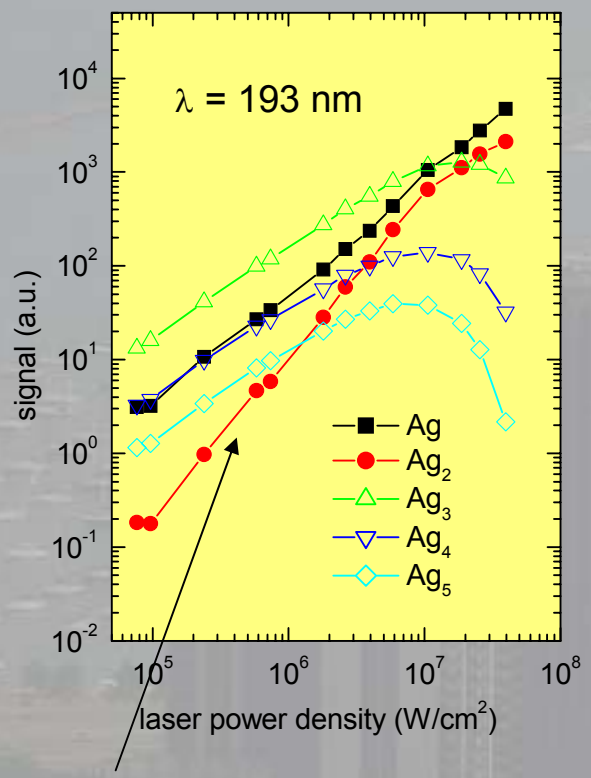
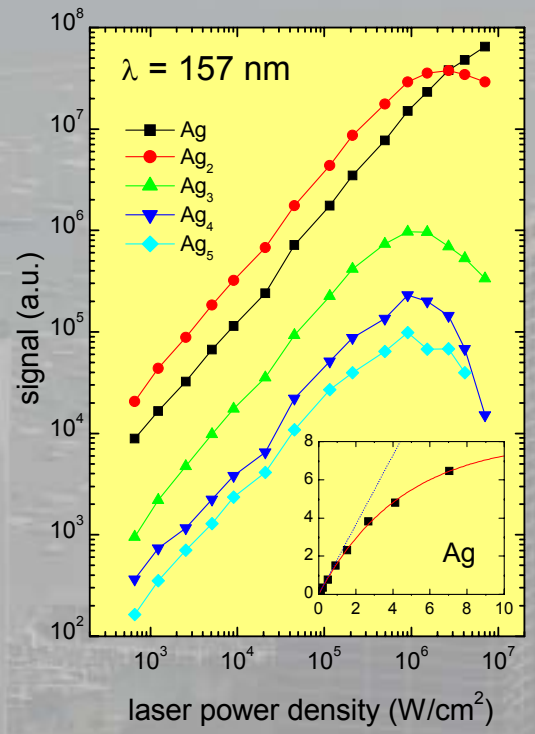
single photon ionization

atoms and clusters sputtered from Ag

$h\upsilon$ = 6.4 eV



$h\upsilon$ = 7.9 eV



Laser intensity dependence not understood for multiphoton ionization !

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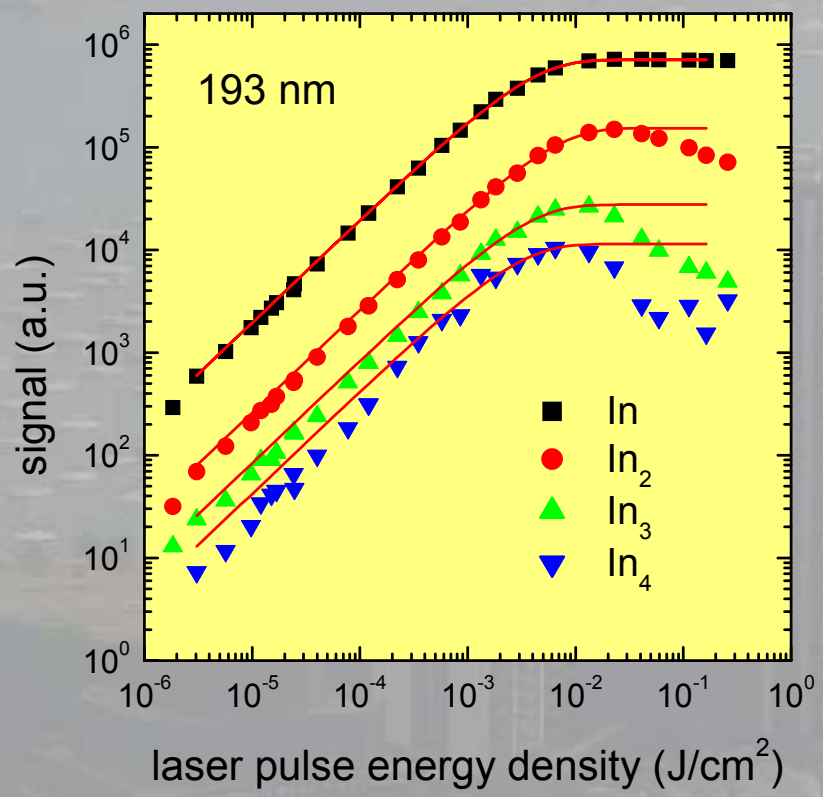
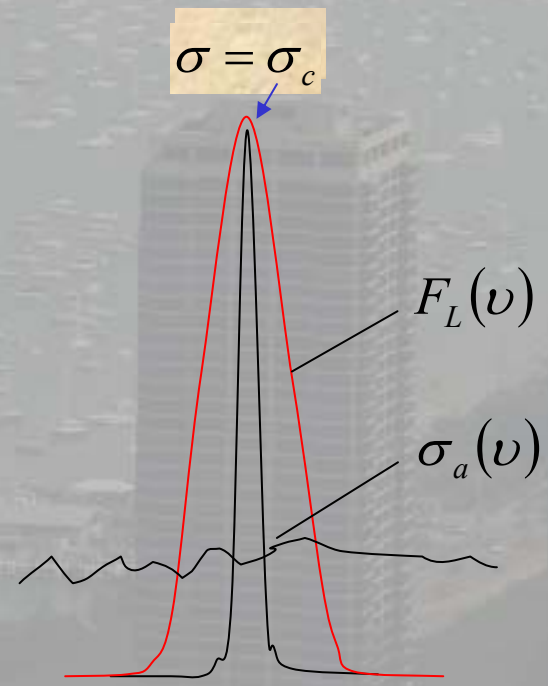
single photon ionization

- ionization rate $R_i = I_L \sigma_i$ → photoabsorption cross section

$$\sigma = \int F_L(\upsilon)\sigma_a(\upsilon)d\upsilon$$

- saturation $p_i = 1 - \exp(-\sigma_i \cdot I_L \cdot t_L)$





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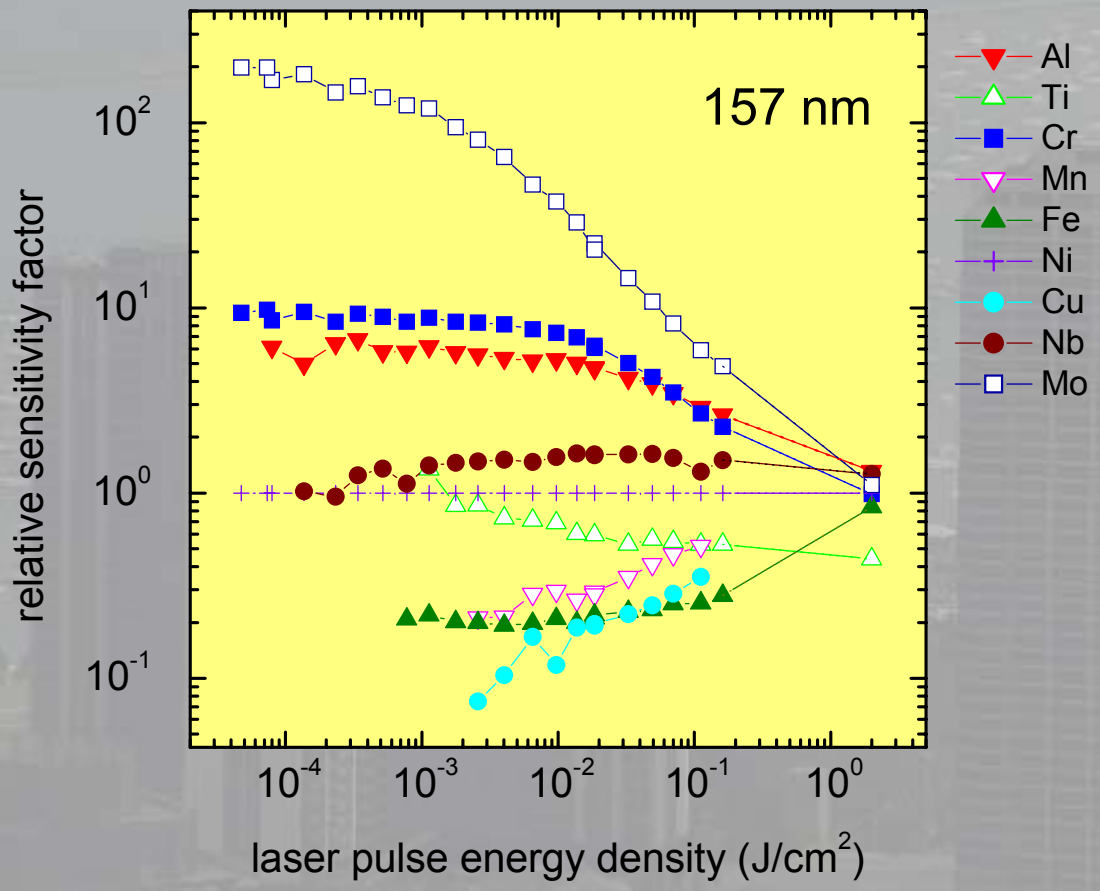
detection sensitivity

Relative sensitivity factor for single photon ionization

NBS 1245a



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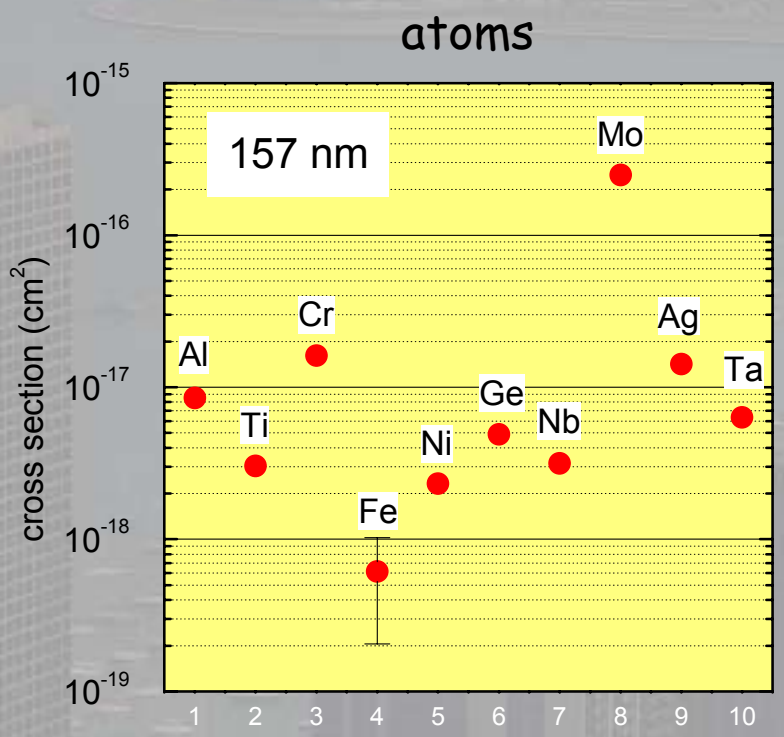
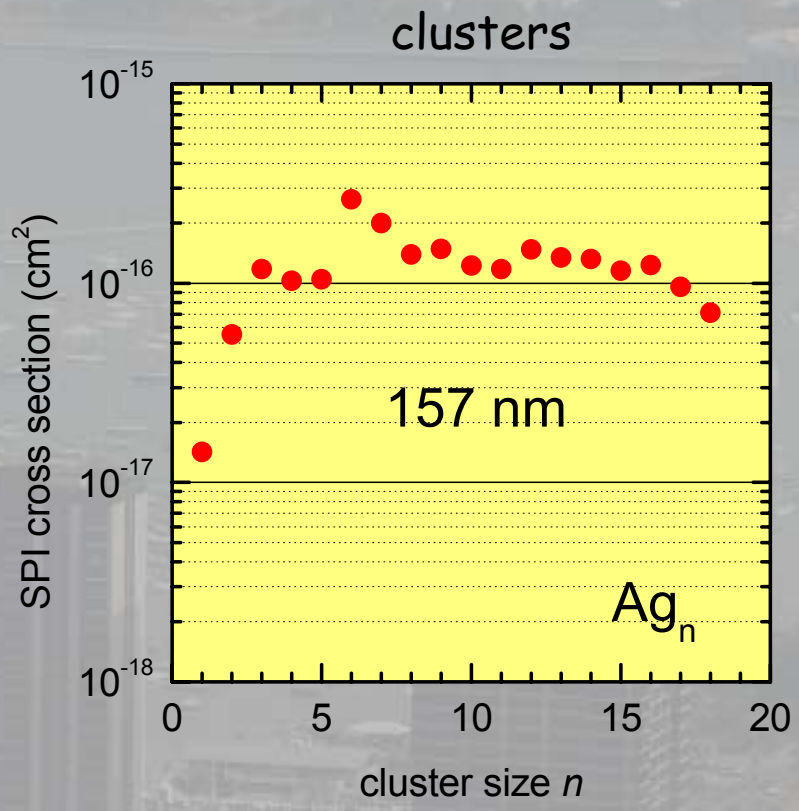
photoionization cross section





Saturation: 10^{17} photons/cm² ⟶ 100 mJ/cm² @ 10 eV

1 mJ into 1 mm spot Ø

10 μJ into 0.1 mm spot Ø

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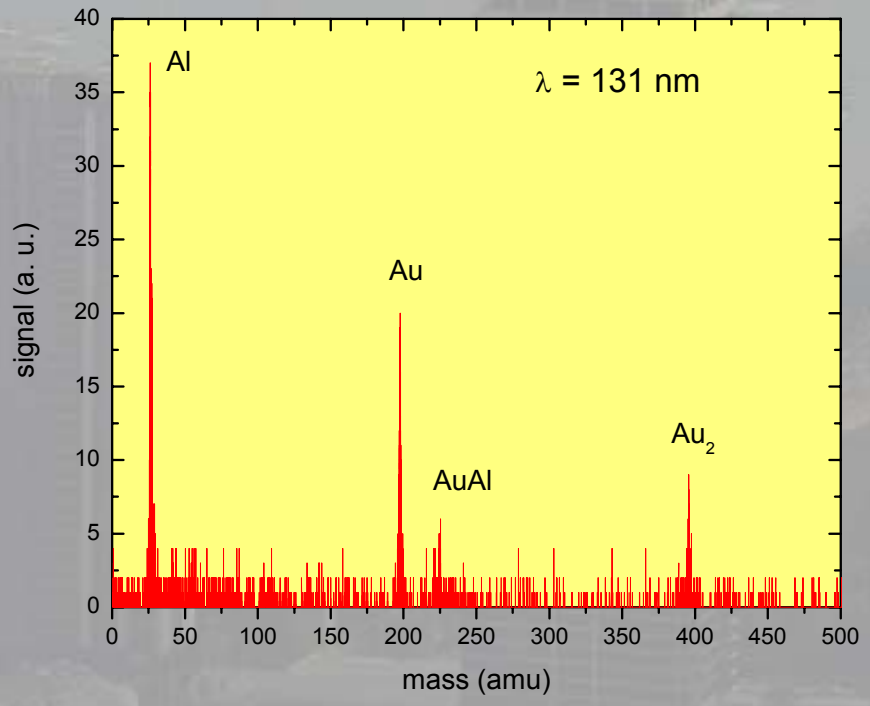
status

- ToF – SNMS system connected to FEL (SPIRIT)
- FEL working ($h\upsilon \leq 10$ eV, 10...100 μJ / pulse)
- single photon ionization of high-IP atoms



Problems :

- shot-to-shot variation of
  - FEL intensity
  - wavelength

strategy

- record FEL
  - wavelength spectrum
  - intensity

  on every single shot

- normalize spectra to FEL intensity

- bin measured spectra according to λ and I
  - reduce focal dimension for σ_i determination
  - Correct for different σ_i