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Laser assisted electron impact excitation of helium in the threshold region

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Synopsis We study the threshold excitation of metastable $He^*(1s2s\,^{1,3}S)$ states by combined electron impact and intense laser radiation (λ = 532 nm/1064 nm, $I = 10^{10}$-$10^{12} W/cm^2$). A new experimental setup is used combining a ns-pulsed electron beam extracted from a photo-cathode, a single frequency Nd:YAG laser beam and a reaction microscope. Fully differential scattering cross sections are obtained by measuring the recoil momentum of the metastables.

Electron scattering in the presence of an intense laser field plays an essential role in many strong field phenomena like single and multiple ionization and high harmonic generation. It is also important, for instance in the laser heating of plasmas and high-power gas lasers.

Electron-atom scattering reactions can be strongly modified by the presence of intense laser radiation. The light field can assist the collision by providing or taking away energy in form of an integer number of photons and its polarization vector imposes an additional distinguished spatial axis. For sufficient intensities the target atom can be dressed and different excited states can be coupled. E.g., in the case of the helium target and a Nd:YAG laser, the photon energy matches the energy difference between $1s2s^3S$ and $1s2p^3P$, leading to a strong AC-Stark mixing.

Here we present first results of a combined experimental and theoretical investigation of laser assisted electron-helium scattering in the threshold region of the $He^*(1snl)$ states. Although some early experiments using CO_2 lasers and one using a Nd:YAG laser [1] exist this process is not well studied (for a review see [2]).

Experimentally we use a new reaction microscope which comprises a pulsed ($\Delta t < 1$ ns) and monoenergetic ($\Delta E < 0.2$ eV) electron beam from a GaAs-photocathode which is crossed by a single frequency Nd:YAG laser beam ($I = 10^{11}$ W/cm^2 for pulse energy $E = 3$ J, duration $\Delta t = 6$ ns, $d = 0.7$ mm) and a supersonic He gas jet. The metastable $He^*(1s2s\,^{1,3}S)$ atoms are detected by a time and position resolving MCP-detector. From their recoil momentum the scattered electron momentum can be determined. The recorded field free metastable excitation cross section over the incident energy is shown in Fig.1. Cross sections for laser assisted excitation and calculations using the R-matrix Floquet method [3] will be presented at the conference.

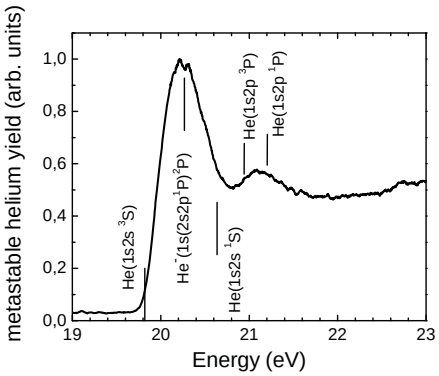

Figure 1. Field free metastable excitation cross section for helium over the incident energy range 19 - 23 eV.

References

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