Journal of Physics: Conference Series **635** (2015) 092134 doi:10.1088/1742-6596/635/9/092134

Excited state distribution and spin-effects in strong-field excitation of neutral Helium

Henri Zimmermann* [1], **Sebastian Eilzer*** **and Ulli Eichmann***,† [2],

* Max-Born-Institute Berlin, Max-Born-Straße 2A, 12489 Berlin, Germany

† Institut für Optik und Atomare Physik, Technische Universität Berlin, 10623 Berlin, Germany

Synopsis We investigated the principal quantum number n distribution of excited states resulting from the interaction of Helium with strong, short laser pulses. We find excellent agreement with predictions of the semiclassical frustrated tunneling ionization (FTI) model [1] as well as fully quantum mechanical calculations. Furthermore, the excitation process directly populates triplet excited states due to the breakdown of the Russel-Saunders coupling scheme for high orbital angular momentum l states of Helium, which are predominantly populated in the strong laser field.

Excitation of neutral atoms via frustrated tunneling ionization [1] is a recently established, important exit channel of atoms subjected to a strong short-pulse laser field. While processes such as the acceleration of the excited neutral atoms in strong intensity gradients ([2],[3]) and Coulomb explosion without double ionization in strong laser field fragmentation of H_2 [4] are convincingly explained within the FTI model, the experimental confirmation of the important prediction on the excited state distribution has been missing so far.

In our experiments we excite neutral Helium atoms under conditions characterized by the tunneling regime of strong-field physics using femtosecond pulses from a Ti:Sapphire laser and employ the method of pulsed field ionization in conjunction with direct measurement of the excited neutral atoms to analyze the distribution of excited states. This approach enables us to obtain a measurement signal proportional to the amount of initially excited atoms with a detection efficiency of approximately 30 %.

Our measurements confirm the predictions [5] of the FTI model as well as quantum mechanical calculations [6] using the single-active electron (SAE) approximation (see figure 1) showing that one can model excitation in the tunneling regime by an almost purely classical process.

Moreover, we find that the excitation process also results in an efficient population of triplet excited states of Helium [5], which results from the fact, that states with high orbital angular momentum $l > 3$ are accessible under our experimental conditions. For these high l states the strict separation into singlets and triplets is removed due to the breakdown of the Russel-Saunders coupling scheme. The direct excitation of triplet states is then possible via the admixture of their singlet component.

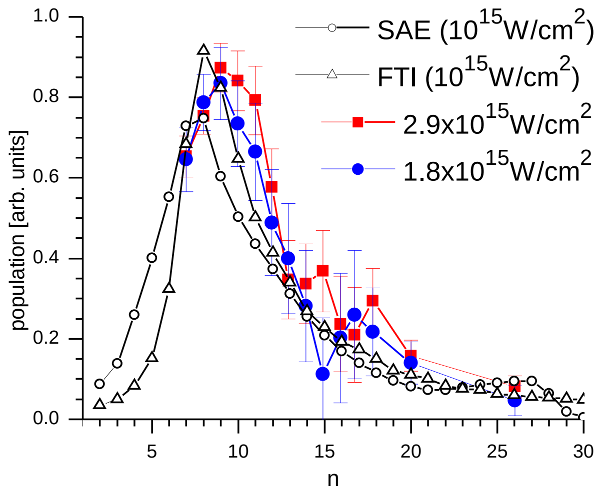

Figure 1. Comparison of measured (filled red squares and blue circles) and calculated (open triangles and circles) n-distributions of Helium.

References

[1] Nubbemeyer T, Gorling K, Saenz A, Eichmann U and Sandner W 2008 *Phys. Rev. Lett.* **101** 233001

[2] Eichmann U, Nubbemeyer T, Rottke H and Sandner W 2009 *Nature* **461** 1261

[3] Eilzer S, Zimmermann H and Eichmann U 2014 *Phys. Rev. Lett* **112** 113001

[4] Manschwetus B, Nubbemeyer T, Gorling K, Steinmeyer G, Eichmann U, Rottke H and Sandner W 2009 *Phys. Rev. Lett.* **102** 113002

[5] Zimmermann H, Buller J, Eilzer S and Eichmann U 2015 *Phys. Rev. Lett.* **114** 123003

[6] Khosravi E and Saenz A (unpublished)

[1] E-mail: Henri.Zimmermann@mbi-berlin.de
[2] E-mail: Ulli.Eichmann@mbi-berlin.de