Monochromatic electron beam from Rydberg atoms

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We develop a source of focused electron and ion beams, through ionization of a high flux effusive atomic beam. The atomic (cesium) beam is obtained from an effusive oven. The low transverse temperature (sub-K range) and the relative density of the starting atomic sample ensure excellent initial conditions in order to obtain a bright and monochromatic (≈1 meV) charged source (Fig. 1(b)). Typically, by photo-ionizing the atomic beam, the energy spread of extracted electrons is limited by chromaticism created during the ionization process, related to the laser's waist. To overcome those effects, we use Rydberg atoms field ionization (Fig. 1(a)).

Here, we present an experimental and theoretical study of the photoexcitation and ionization of high quantum defect states, using excitation from the 7s state in cesium to Rydberg states in the presence of a uniform electric field [1]. Such states can exhibit complex ionization behavior, for instance, highly localized growth in the ionization rate due to interference effects. We observe that large changes in the Rydberg ionization rate from small changes in electric field are possible when a nearly stable state crosses a more unstable state (Fig. 1(c)). A fast variation of the ionization rate with electric field allows for the production of charged beams with very low energy spread.

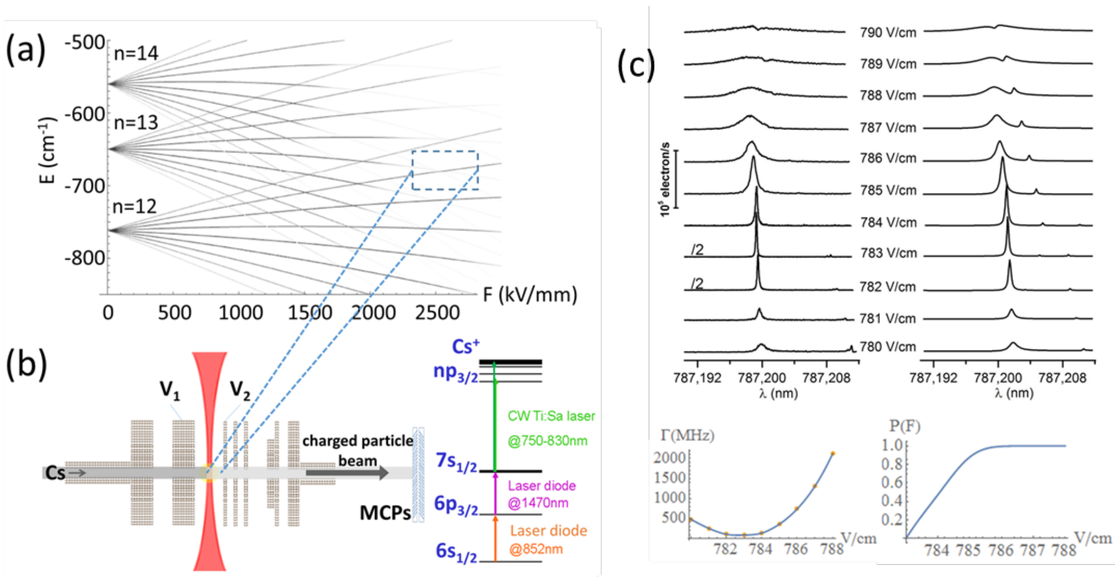

Fig. 1: (a) and (b) Principle of ion or electron beam production using sharp Rydberg forced field ionization. Electrons and ions are produced by laser excitation of Rydberg states that are then field ionized. (c) Scan of ionization rate versus wavelength for varying field, displaying interference narrowing.

References

[1] E. Moufarej *et. al.*, Physical Review A, **95**, 043409 (2017)

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