Abstract

This work is an attempt to explain some of physical properties of Rydberg matter by analysis deduced from the results of measurements using photon-matter interactions. Rydberg matter is a condensed phase formed by Rydberg species. Interactions of Rydberg matter with photons of a laser beam or in stimulated emission in the experiments are presented here. The novelty of Rydberg matter, its interesting properties, as well as possible applications of this matter are the motivations for these studies.

Experiments on Rydberg matter is conducted by several different methods. Time-of-flight methods with pulsed lasers is used for the larger part of the experiments presented in this thesis. This method enables identification of the constituents of the formed Rydberg matter. Until now Rydberg matter clusters of K, H_2, N_2, and H have been studied by this method. Time-of-flight measurements also give information on the structure of the Rydberg matter, such as bond distances. This is possible by studying the energetics of the fragments detected in the laser induced fragmentation process known as Coulomb explosion. Angular distributions of the Time-of-flight of the particles enables in depth analysis of the fragmentation processes.

Theoretical studies using classical mechanics calculations predicts properties such as cluster-cluster interaction strength, the interaction potential barrier as function of distance between Rydberg matter clusters, as well as the magnetic properties of the interacting clusters. Standard quantum mechanics calculations based on a perturbation theory, give estimates of normal modes of vibrations of Rydberg complexes. These Rydberg complexes are detected at a catalyst surface in the stimulated micro-Raman spectroscopy study presented in this thesis.

Rydberg matter is shown to have some very interesting applications. K Rydberg matter is used as the lasing medium in a broadband tunable laser for the infrared region of the spectrum from 1 μm to 14 μm. Rydberg matter is also involved in formation of H RM that may be metallic hydrogen. Rydberg matter was suggested as a candidate for the dark matter in the universe and the magnetic properties of the matter suggest that it may exists in the interstellar space.

KEYWORDS: Rydberg matter clusters, Rydberg states, Time-of-flight, Coulomb explosion, Multiphoton ionization, Stimulated emission.

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