Atomic Cluster Introduction

Physicists and chemists have been fascinated in atomic clusters since their discovery in the mid 1950s [1] because of the unique position clusters hold as an intermediate state between molecules and solids. While the optical properties of clusters have been studied for some time at low intensity, the advent of chirped pulse amplification (CPA) lasers [2] has allowed atomic clusters to be exposed to laser intensities in the range 10^{15} â€“10^{17} W cm^{-2} (laser pulse durations in the range 0.1â€“10 ps), where the electric field of the laser is greater than atomic binding fields (the so-called non-perturbative regime) and where the wiggle energy of a free electron in the laser field (the ponderomotive potential) is in the range 0.1â€“10 keV [3]. Following the first observation of â€˜â€˜anomalousâ€™â€™ X-ray lines from clustered gas targets in the early 1990s [4], many subsequent experimental studies (cited below) have shown that under intense, short pulse irradiation, clusters of size in the range 500â€“10^6 atoms become a source of bright X-rays, fast electrons (a few keV) and energetic, highly charged ions (up to 1 MeV and 40^+). This interaction is distinct from the Coulomb explosion dominated dynamics observed in clusters at lower intensity, and much more energetic than that of the well-studied cases of atoms [5â€“7], molecules [8,9] and small (< a few hundred atoms) clusters [10,11] in intense laser fields. In terms of the efficient coupling of laser energy to electrons and ions, the laser cluster interaction is more akin to the bulk solid interaction [12], i.e. displaying plasma-like behavior. It should also be noted, that these nanometer scale clusters are considerably smaller than micron size droplets [13] and most micro-structured targets that have been studied for some time [14].

In this paper, following a brief description of cluster formation, an introduction to the physics of the laserâ€“cluster interaction will be provided, largely in the framework of the â€˜â€˜nanoplasma modelâ€™â€™ [15]. This model treats the cluster in the strong laser field as a nanometer-scale spherical plasma, subject to the standard laserâ€“plasma processes, such as inverse Bremsstrahlung heating, but taking into account the unique target geometry. Some illustrative examples of experimental results on ion emission from clusters will be summarised. Finally, some applications of the laserâ€“cluster interaction will be presented, namely efficient debris-free X-ray generation and pulsed neutron production via nuclear fusion in deuterium clusters.

See Also

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atomic Atomic Cluster Application Atomic Cluster Charge build-up Atomic Cluster Expansion Atomic Cluster Experimental Apparatus Atomic Cluster Heating Atomic Cluster Ionization Atomic Cluster Nuclear Fusion Atomic Cluster X-Ray Emission Atomic Clusters Atomic Force atomic mass atomic number atomic theory atomic triplet atomic weight diatomic Figure 13.06 - Atomic Subdivision Force-Atomic Formation of Atomic Clusters Interaction of Intense Laser Pulses with Atomic Clusters - Measurements of Ion Emission Simulations and Applications InterAtomic Ion Energies from Atomic Cluster Explosions Law of Atomic Dissociation Law of Atomic Pitch Law of Oscillating Atomic Substances Law of Pitch of Atomic Oscillation Law of Variation of Atomic Oscillation by Electricity Law of Variation of Atomic Oscillation by Sono-thermism Law of Variation of Atomic Oscillation by Temperature Law of Variation of Atomic Pitch by Electricity and Magnetism Law of Variation of Atomic Pitch by Rad-energy Law of Variation of Atomic Pitch by Temperature Law of Variation of Pitch of Atomic Oscillation by Pressure monatomic Numerical Simulation of an Atomic Cluster Explosion subatomic