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Self-Similar Size Distribution of Atom Clusters in Cooling Vapors

YONG W. KIM, HEDOK LEE, PAUL BELONY, JR., Lehigh University — Aluminum atom clusters of nanometer dimensions grow out of dense vapors. We have both measured and modeled their formation process by first creating dense atomic vapors as remnants of a 3-D laser-produced plasma plume from a solid aluminum target. By real-time diagnosis, we have fully characterized the plume into more than 140,000 vapor cells. [Kim, Lee, *Rev. Sci. Instr.* **75**, 3953 (2004)] Clustering of atoms in each cell has been followed during the cooling of the vapors by numerical simulation of atom-atom and atom-cluster collisions. The distribution of clusters by size evolves as the vapor cools, and is sensitively dependent on the initial atom density in each plasma cell. When the population and cluster size are rescaled as fractions of their respective maximal values, the distribution functions all collapse into a single functional form regardless of the time in the evolution or the initial value of the vapor density. The maximal population decreases while the maximal size grows over time. The cluster size distribution for the plasma plume is found by summing the distributions from all plasma cells. Independently, the clusters are captured onto electron microscope grids and size analyzed by means of transmission electron microscopy. The computed result is in excellent agreement with the measured histogram of clusters by size. The agreement is absolute, indicating the Brownian motion nature of cluster-cluster interaction.

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