Large Helium Droplets from Pulsed Source

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Synopsis A modified electromagnetic pulsed valve has been used to produce large helium droplets. We discuss the optimal cooling of the valve by a close cycled refrigerator. As a result low temperature of the nozzle of T < 5 K could be reached during operation at 20 Hz. Production of He droplets containing up to 10^{11} atoms is reported.

Helium (He) nanodroplets have long been used as cryogenic matrices for spectroscopy of ionic and neutral clusters and complexes.[1] The continuous cryogenic expansion at temperatures as low as 5 K, has been used to produce large droplets containing up to about 10^{12} atoms with diameter up to about 2 μm.[2,3] On the other hand, it is much more difficult to reach low temperature with a pulsed electromagnetic valves due to ohmic heat release during the operation. Pulsed helium droplet beam yields much larger peak droplet density, which correspondingly assures larger signals if pulsed laser or electron beam techniques of interrogation are applied. It is for these reasons that pulsed He droplet beam would prove advantageous in experiments on coherent diffractive imaging with free electron lasers, as described in our recent publications.[2,3,4,5]

Here we report on the formation of large sized helium droplets, $\langle N_{He} \rangle = 10^5$-$10^{11}$, from a modified Parker Series 99 pulsed nozzle valve at stagnation pressures of 5 and 10 bar and temperatures of 4-15 K with a nozzle diameter of 0.5 or 1 mm. The average sizes were obtained by attenuation of the droplet beam with collisional helium gas at room temperature.[6] Additionally, the helium flux ejected from the nozzle was estimated using a sensitive fast ionization gauge, which showed ~100 times larger values as compared to a continuous beam source, as previously reported.[7] Ratio of M = 16 to M = 8 intensity peaks were furthermore investigated at different nozzle temperatures using a quadrupole mass spectrometer (QMS) which utilizes an electron impact ionizer. At lower nozzle temperatures, the ratio increases due to new pathways of He_4^+ ion production in large droplet. The pulsed valve setup comprises of the nozzle part shielded within a copper enclosure providing effective thermal contact between the pulsed valve body and the second stage of the close cycle refrigerator. The result is lower nozzle temperatures down to ~ 4K, which is almost twice lower than attainable temperatures in our earlier setup.[6,7]

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References

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