Fragmentation of doubly and triply charged mercury clusters

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As a mercury atom has an electronically closed shell structure, the van der Waals dispersion force dominates in the binding of small mercury clusters. As the cluster size increases, the metallic property appears [1]. Sato and coworkers observed fragmentation of doubly and triply charged mercury clusters [2]. Parent clusters are produced by ion bombardments on amalgam surface. Fragment size distribution in the decay of doubly charged clusters was observed. The appearance size, the minimum size that a multiply charged cluster is stable, is measured for doubly and triply charged clusters.

We make an analysis on this experiment to reveal the mechanism of fragmentation. In the upper panel of Fig. 1, we show the measured fragment size distribution in the fission $Hg_n^{2+} \rightarrow Hg_m^+ + Hg_{n-m}^+$ for parent size n = 11 as a function of fragment size $m(> 2/n)$. As shown the figure, nearly symmetric fission (m = 6 and 7) are predominantly observed. In the lower panel, we show the energy barrier E_b in this fission calculated with a liquid drop model proposed by Echt et al.[3]. The energy barrier is lower for nearly symmetric fission and is higher for strongly asymmetric fission. The calculation well explains the experiment. It means that small mer-cury clusters behave as van der Waals clusters.

In table 1, we show two types of critical sizes, n_{c1} and n_{c2} calculated with this model. The former corresponds to the size where all the fragmentation path has a finite energy barrier while the latter the size where the fission barrier exceeds the monomer evaporation energy. The measured appearance sizes are found to be close to n_{c2}. This fact means that clusters are internally so excited that fission and evaporation takes place competitively.

Table 1. Appearance sizes for Hg_n^{z+}, calculated and measured values.

z	n_{c1}	n_{c2}	experiment [2]
2	14	22	20
3	27	41	46

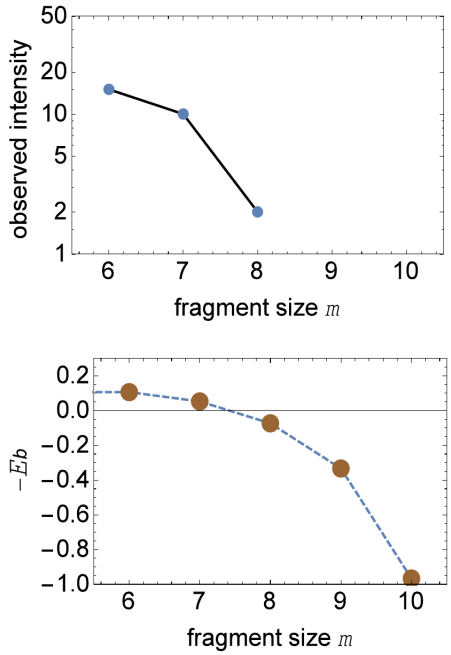

Figure 1. The upper panel is logarithmic plot for product size distribution in $Hg_{11}^{2+} \rightarrow Hg_m^+ + Hg_{11-m}^+$ [2] and the lower panel shows the energy barrier E_b as a function of fragment size m.

References

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