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Cluster size distributions of MeV particle induced desorption of frozen water targets described by coalescence growth

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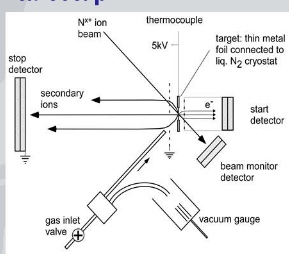
Introduction

Water ice is well known for producing an abundant yield of molecular clusters when bombarded by energetic projectiles [1,2]. When studying the size distribution of sputtered clusters several attempts were made in order to understand their mechanism of formation. In this work, the predictions for the mechanism of coalescence growth will be applied in order to describe the observed yield in the cluster desorption in water ice targets induced by MeV nitrogen projectiles.

Experimental Setup

Thin ice layers (typically 150 ± 50 nm) were condensed from vapour on a thin copper substrate (100 nm) cooled by a liquid nitrogen cryostat. The system is kept under high vacuum (8 x 10^{-7} mbar).

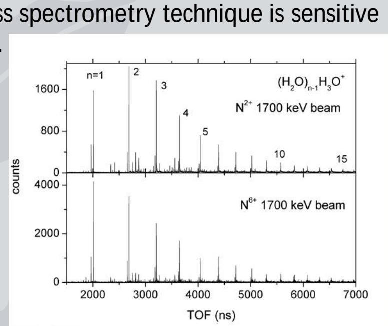


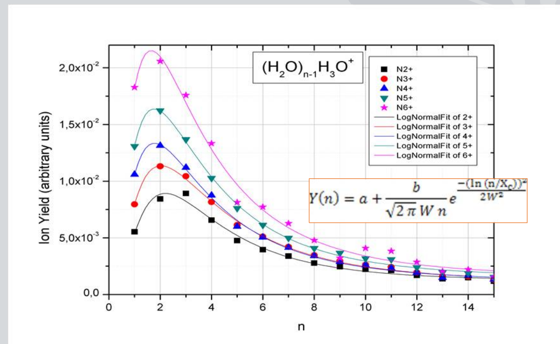
The ice layer is bombarded at 45° by a N beam (1,7 MeV with charge states from 2+ to 6+) from the Van de Graaff accelerator (PUC-Rio). Secondary ions emitted from the surface are analyzed by a time-of-flight (TOF) spectrometer.

Results and Discussion

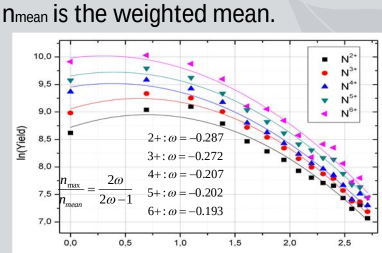
The abundance distribution of the clusters change with the charge state of the incoming projectile. Note that besides the projectile charge state fastly moves to equilibrium as it penetrates the target, we can observe the charge state effect because our mass spectrometry technique is sensitive to the first monolayers.

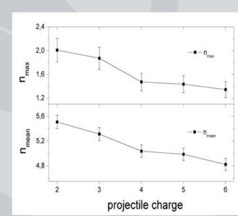
In the properly normalized spectra, the yield for each cluster is calculated. It is seen a systematic increase in the ion yield with charge state, specially for the smaller clusters.





In order to describe the observed behaviour of the cluster abundance with charge state we used solutions found in a model describing the **cluster growth via a coalescence mechanism** [3] whose long term solution is a **lognormal** function. According to model´s prediction the distribution observed for lower charge state projectiles (more negative "kernel homogeneity **ω**") indicates a larger fractal dimension for the clusters. Clusters with larger fractal dimensions are less compact and have more sites available to add new molecules, increasing the mean cluster size. In the log-log plot below, the most probable value n_{max} is calculated from a quadratic fitting function and mean value n_{mean} is the weighted mean.





Final Remarks

The measured distributions of water clusters desorbed from an icy target by N 1,7 MeV projectiles with different incoming charge states are analysed by a coalescence growth model. Results indicate that lower charge state projectiles results in less compact cluster distributions with larger fractal dimension and higher mean size. The distributions here shown differs from the classic case of coalescence mediated by atom transport between nucleation sites (Ostwald ripening) which predicts distibution with tail extending towards smaller clusters.

Apoios:

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