AF33 -0232 Aerosol nucleation induced by a high energy particle beam

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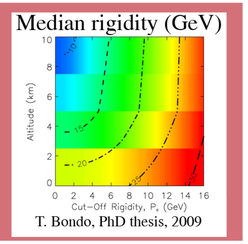
INTRODUCTION

The effect of ions in aerosol nucleation is a subject where much remains to be discovered. That ions can enhance nucleation has been shown by theory, observations, and experiments. However, the exact mechanism still remains to be determined. One question is if the nature of the ionization affects the nucleation. This is an essential question since many experiments have been performed using radioactive sources that ionize differently than the cosmic rays which are responsible for the majority of atmospheric ionization.

Here we report on an experimental study of sulfuric acid aerosol nucleation under near atmospheric conditions using a 580 MeV electron beam and a 511/1275 keV Na-22 gamma source to ionize the volume of the reaction chamber.

Gammas vs. Electrons

Low energy gamma rays will ionize very locally whereas the 580 MeV electrons are minimum ionizing and will ionize along their path. The figure shows energies required to ionize the atmosphere and the electrons are much closer to the required energies than the gammas.



T. Bondo, PhD thesis, 2009

SETUP

We used a 50 L electropolished stainless steel chamber. Collimated UV light entered through a Teflon foil to start the oxidation of SO_2 into sulfuric acid that condense with water to form aerosols. Aerosols and trace concentrations of ozone and SO_2 were measured along with temperature, pressure, and humidity. A continuous flow of 3.1 L/min of clean, humidified, synthetic air went through the chamber, which was kept at 1 mbar overpressure at all times.

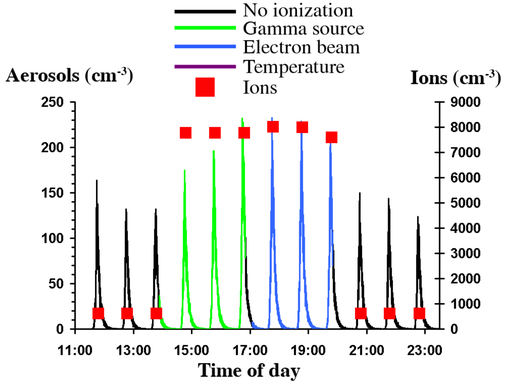
An insulated box with temperature controlled air kept the chamber temperature stable to below a tenth of a degree.

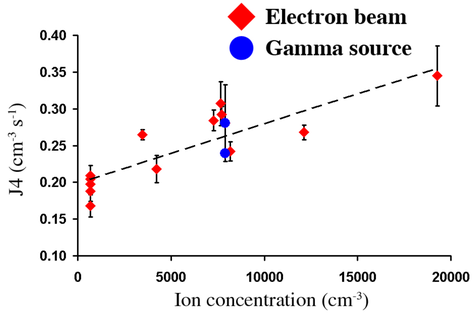
The experiment was run by turning on the UV for 10 minutes to create a burst of sulfuric acid and thus aerosols. These aerosols were measured using a TSI 3775 with a cut-off diameter around 4 nm. Between bursts the ionizing radiation could be varied.

RESULTS

The figure below shows 12 nucleation bursts with varying ionization levels and sources. Similar results are achieved using gamma rays and electrons.

To the right is seen the appearance rate of 4 nm aerosols (J4) as a function of ion concentration.

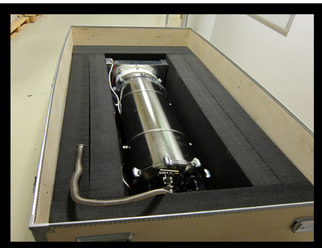


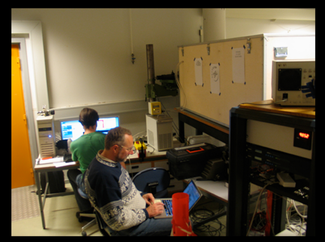


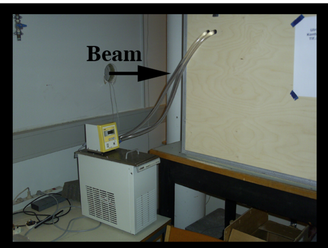
CONCLUSION

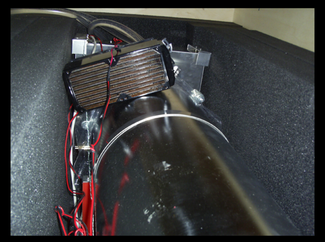
The main result from this work is that nucleation induced with ionization from the gamma source is indistinguishable from that using the electron beam. This indicates that the fraction of nucleation due to the electron beam or the gamma rays is an effect of the produced ions and that the nature of the ionizing particles is not important.

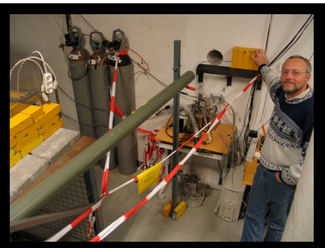
The result greatly facilitates future laboratory studies of ion induced aerosol nucleation, which can more easily be done with gamma radiation sources instead of using complicated and expensive accelerator beams.











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