

# BSMA3

<http://www.arel.ee>  
<http://ael.physic.ut.ee/tammet>

is the third and improved model of the

## Balanced Scanning Mobility Analyzer

(Tammet, 2006, <http://dx.doi.org/10.1016/j.atmosres.2006.02.009>), which makes possible simultaneous measuring of positive and negative air ion distribution in the mobility range of  $0.032\text{--}3.2\text{ cm}^2\text{V}^{-1}\text{s}^{-1}$  and in the size range of  $0.4\text{--}7.5\text{ nm}$ . The instrument is designed having in view applications in atmospheric aerosol nucleation research. It provides routine monitoring of cluster ions and charged nanometer particles in atmospheric air. The distinctive properties of BSMA3 are:

- High flow rate about  $40\text{ dm}^3/\text{s}$  assures representative sampling of the atmospheric air.
- The sheath air is aspirated into the instrument directly from the atmosphere together with the analyzed air and flows during the same air tract.
- Short passage time  $0.1\text{ s}$  and low heating of air less than  $0.3\text{ K}$  suppress altering of the ions during the measuring.
- Calibration of the instrument is based on the geometric dimensions, air flow rate, resistances, and voltages.
- Low inlet loss of ions enables reliable estimating and numerical compensation.
- Temperature- and pressure- sensitive calibration coefficients are operatively adjusted during the measurement according to the readings of built-in meteorological sensors.
- The single-channel scanning guarantees that peculiarities in the recorded mobility distribution are not generated by the technical troubles specific for individual channels.
- The size range of  $0.4\text{--}7.5\text{ nm}$  corresponds to the aerosol nucleation range.
- The methods of calibration are explicitly described in the attached documentation and the source code of the internal data processing is open and available for the user.

The clusters and the smallest nanoparticles are the subjects of rapid transformations and their composition can be changed when the air is heated during the passage through the inlet tract and the mobility analyzer. Thus the residence time of the air in the instrument should be short, the heating and drying of the air should be minimized, and the temperature and humidity of the sheath air should be kept the same as in the analyzed air. This was a high-priority requirement considered in the design of the BSMA3. Another high-priority requirement was the suppressing of inlet losses of the highly diffusive clusters and nanoparticles. The estimation of the inlet penetration rate includes a considerable uncertainty and complicates the calibration of the instruments. The relative uncertainty of penetration is suppressed by minimizing the inlet loss of ions.

The problems with distortion of recorded distributions by possible technical troubles in individual mobility channels are avoided in the BSMA3, where all ions are collected onto the same electrode and the mobility is varied by the variation of the analyzer voltage. The accompanying induced current, which exceeds the ion current many orders of magnitude, is compensated in the BSMA by means of a balanced bridge circuit.