Dataset OneSecondAirIons_2011_1

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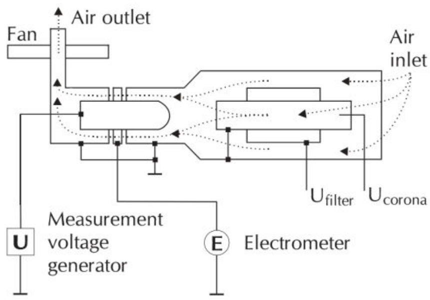
Introduction

Air ions are charged airborne particles, which can be classified according to their electric mobility or geometric size, as well as by chemical composition. The electric mobilities of the ambient ions can be directly determined by measurements, whereas the equivalent diameters can be estimated by sophisticated theories of mobility-size conversions. A classic survey of atmospheric ions is available in a monograph by Israël (1970). The charged molecules and clusters up to 1.6 nm in diameter are called small air ions, the charged aerosol particles of size 1.6–7.4 nm and size 7.4–70 nm are called intermediate air ions and large air ions, respectively (Hõrrak et al., 2000). Characteristics of the air ions can be used to trace and/or explain several phenomena within the air. For example, the chemical composition of small air ions is known to be sensitive to the concentrations of several air trace gases in the air, significantly depending on the age of the ions (Luts and Salm, 1994; Luts, 1995; Parts and Luts, 2004). Variations in the ion chemical composition can induce variations in the particular mobility distribution of the ions. Therefore, a device that can record the mobility (or size) distribution of airborne small ions, with considerably high accuracy and mobility resolution, can be used as detector of trace level air impurities, besides the general study of the air ion evolution. An unique device of this kind has been developed in Air Electricity Laboratory of Tartu University (Tammet et al., 1977; Tammet, 2011). This device called UT-7509 can record the mobility distribution of corona-generated ions between 0.6 and 2.8 $cm^2V^{-1}s^{-1}$ with high mobility resolution. The mobility equivalent diameters are between about 0.42 and 1.5 nm (Tammet, 1995; 2012). The age of these corona generated ions (determined by the airflow rate of spectrometer) is about 1 second. This aspiration method is substantially different from a relatively widespread technique of drift-tubes that is also called "ion mobility spectrometry", which commonly measures the air ions that are only few millisecond old. The chemical composition and structure of millisecond-ions is rather different from the composition of older ions (e.g., 1 second old) and, therefore, the information obtained from the measurements of older ions can contain considerable additional value (Luts and Salm, 1994; Luts, 1995).

Description of the measurements and the data



The measurements were carried out in the old building of Department of Physics of Tartu University (Tähe 4, 51010, Tartu, Estonia 58.373 N, 26.727 E, 65 m a.s.l., *see* the picture of the building in the right-side). The instrumentation was installed on the top of 5-stored building, in the room on the attic story to sample the outdoor air. Simplified scheme of the air ion spectrometer (differential mobility analyser) UT-7509 is depicted below this picture. Fan draws the ambient air through the device. Most of the ambient ions are removed by electro filter, at the same time corona generates large amount of new ions, many orders of magnitude exceeding the concentrations of ambient small ions. These new ions participate in numerous (ion-molecule) reactions with the constituents of the air and after about 1 second the ions that are formed within these reactions enter the mobility analyser and are deposited onto the sections of measurement condenser. This is so called scanning type second order differential mobility analyser, which response to the measured air ion concentration of different mobilities is characterised by the apparatus function (Tammet, 1970). The mobility distribution of air ions is obtained by changing the voltage applied on the mobility analyser. Every single raw mobility distribution of the positive and negative air ions of one polarity contains 114 values, obtained at specific limiting mobilities of ion spectrometer determined by the airflow rate and selected voltages. These limiting mobilities are selected so that they cover nearly equally in logarithmic scale all the interested mobility range of ions between 0.6 and 2.8 $cm^2V^{-1}s^{-1}$ and summing up over the measured fraction concentrations gives the total ion concentration in the entire mobility range. These raw values characterize the concentrations of the ions at certain sub-range of mobilities, for strictly correct calculations the apparatus equation of ion spectrometer should be solved in accordance with method given by

Tammet et al. (1987). The simplified method, where the measured raw data are interpreted as fraction concentrations, yields somewhat smoothed mobility spectra. However, the differences compared to the stricter method, are small and the uncertainties do not exceed few per cents (Tammet et al., 1987).

Within every 5 minute the distributions of the ions of both signs are recorded.

To form the presented dataset, the raw data of scanning voltages are converted into the mobility scale (strictly: into limiting mobilities), using the equation

$$Mobility = A * \frac{air\ flow\, rate}{voltage * capacitance}$$

where *A* is a constant that provides the correct units; [*air flow rate*], [*capacitance*] and [*voltage*] are the parameters describing the measurement condenser. The limiting [*mobility*] is considered to be equal with the mean mobility of a particular ion concentration recorded at particular [*voltage*] (Tammet et al., 1977). After that the obtained mean mobilities of small air ions are reduced to standard conditions (20 C, 101325 Pa), using the actual (simultaneously measured) values of temperature and pressure and the algorithm, presented by Tammet (1998). This reduction eliminates the shift of ion mobility due variations in temperature and pressure. The temperature, as well as the air relative humidity, is measured by the sensor at UT-7509, the pressure is obtained from the data acquired by meteorological station, located at the roof of the same building.

Details of the dataset

The dataset contains two tables, one for positive small air ions and another for negative ions. The tables are presented in the form of text files where the values within two different sequential columns are separated by one tabulator. Such text files can be imported into several software programs suitable for data analysis (e.g., MS Excel).

First rows of the tables contain the headings of the corresponding columns, all fields are in text format, separated by tabulator. Second rows of the tables (beginning from the element 9, *see* Table 1 below) contain the mean mobilities of particular ion fractions, the concentrations of the fractions are presented in the corresponding columns of next rows. So, the second row contains the mobility scale of air ion mobility distribution. The mobility scale can also be presented by equation

$$Z_i = Z_0 * A^i, \text{ where A = 1,0138; } Z_0 = 0{,}605\ cm^2V^{-1}s^{-1} \text{ and i is fraction number.}$$

In the second rows of the data tables, the mobilites are multiplied by 1000 and are given as integers, converted to text. Each subsequent particular row (from the 3-th row) within the tables presents a particular full record that contains the following parts:

1) The time when this distribution was recorded, in the form of five integers (year, month, day, hour, minute). Therefore, time occupies columns 1–5. The time is local standard time (UTC + 2 hours).
2) The meteorological parameters (T, RH, pressure). T is given in degrees Celsius. Relative humidity RH is given in per cents (the ratio of actual water vapour density to the saturation density at given temperature, multiplied by 100). Pressure is given in hectopascals. All values are presented as integers (in text format) and occupy columns 6–8.
3) The full mobility distribution of the ions at this time point. The distribution contains 114 values, each value is proportional to the concentration of air ions within a particular mobility range (fraction), where the mobility is calculated from the voltage of the measurement capacitor, at which this concentration was recorded. Negative values are caused by instrumental noise. More in detail, the distribution of air ions according to mobility is described by the fraction concentrations and the mobility presented in the second row of a particular column (Z_0) is the midpoint of this particular mobility range (fraction). In detail, the value in a particular column is the summary ion concentration within this particular fraction whereas the fraction is limited by the mobilities Z_0–a and Z_0+b , where *a* is the half-width of the preceding fraction and *b* is the half-width of the subsequent fraction (*see* table 1 below). All values are presented as integers (in text format) and occupy columns 9–122.
4) The optional comments in the form of free text. If present, they occupy column 123.

Table 1 below contains detailed description of a particular record.

The 114 values that constitute the mobility distribution record are given in arbitrary units. It means that all the numerical values are proportional to the actual ion concentrations, but they are not equal to the concentrations because the factor of proportionality is generally unknown. This limitation cannot be considered a serious drawback because in this case (corona-generated ions with an age of about 1 second) the main information is contained within the shape of a particular size distribution, which does not depend on the (unknown) factor of proportionality.

As a rule the tables contain one full record in every 5 minutes. The main exception is caused by regular zero adjustments. The results of zero adjustments are not included, they are already taken into account within the conversions, but the corresponding rows are missing and in such cases the time gap between two successive rows (records) is larger than 5 minutes. In addition, the tables do not contain the results that are partially incorrect. In such cases the time gap between two successive rows (records) is also larger than 5 minutes.

An example figure depicts several typical shapes of the mobility distributions, obtained from the recordings of our measurement device. It also depicts the effects of certain trace gases, where (1) is induced by $(CH_3)_2SO$, (2) by $(CH_3)_2C_2H_5N$, (3) by $(C_4H_9)N$, (4) by $(C_6H_5)CHO$, and (5) by $(CH_3)CN$. In general, these distributions can be used to derive several new (scientific) information about the evolution of the air ions (Parts and Luts, 2004; Luts *et al*., 2011).

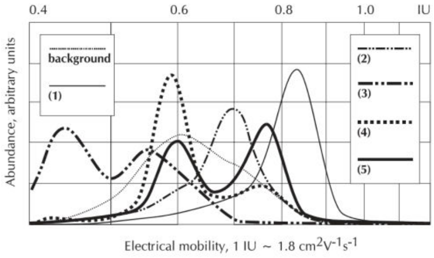


Table 1. Detailed description of a data record.

Column No	Excel column	Header	Value	Range, $cm^2V^{-1}s^{-1}$
1	A	Year	Year number	
2	B	Month	Month number	
3	C	Day	Day number	
4	D	Hour	Hour number	
5	E	Minute	Minute number	
6	F	Temperature	Temperature in degrees Celsius, integer	
7	G	Pressure	Pressure in hectopascals, integer	
8	H	Humidity	Relative humidity in per cents, integer	
9	I	Fraction 1	Value proportional to the summary concentration within this mobility range, integer (in text format)	0.601–0.609
10	J	Fraction 2	… proportional to concentration …, integer	0.609–0.618
11	K	Fraction 3	… proportional to concentration …, integer	0.618–0.626
12	L	Fraction 4	… proportional to concentration …, integer	0.626–0.635
13	M	Fraction 5	… proportional to concentration …, integer	0.635–0.644
14	N	Fraction 6	… proportional to concentration …, integer	0.644–0.653
15	O	Fraction 7	… proportional to concentration …, integer	0.653–0.662
16	P	Fraction 8	… proportional to concentration …, integer	0.662–0.671
17	Q	Fraction 9	… proportional to concentration …, integer	0.671–0.680
18	R	Fraction 10	… proportional to concentration …, integer	0.680–0.689
19	S	Fraction 11	… proportional to concentration …, integer	0.689–0.699
20	T	Fraction 12	… proportional to concentration …, integer	0.699–0.708
21	U	Fraction 13	… proportional to concentration …, integer	0.708–0.718
22	V	Fraction 14	… proportional to concentration …, integer	0.718–0.728
23	W	Fraction 15	… proportional to concentration …, integer	0.728–0.738
24	X	Fraction 16	… proportional to concentration …, integer	0.738–0.748
25	Y	Fraction 17	… proportional to concentration …, integer	0.748–0.759
26	Z	Fraction 18	… proportional to concentration …, integer	0.759–0.769
27	AA	Fraction 19	… proportional to concentration …, integer	0.769–0.780
28	AB	Fraction 20	… proportional to concentration …, integer	0.780–0.790
29	AC	Fraction 21	… proportional to concentration …, integer	0.790–0.801
30	AD	Fraction 22	… proportional to concentration …, integer	0.801–0.812
31	AE	Fraction 23	… proportional to concentration …, integer	0.812–0.824
32	AF	Fraction 24	… proportional to concentration …, integer	0.824–0.835
33	AG	Fraction 25	… proportional to concentration …, integer	0.835–0.847
34	AH	Fraction 26	… proportional to concentration …, integer	0.847–0.858
35	AI	Fraction 27	… proportional to concentration …, integer	0.858–0.870
36	AJ	Fraction 28	… proportional to concentration …, integer	0.870–0.882
37	AK	Fraction 29	… proportional to concentration …, integer	0.882–0.894
38	AL	Fraction 30	… proportional to concentration …, integer	0.894–0.907
39	AM	Fraction 31	… proportional to concentration …, integer	0.907–0.919
40	AN	Fraction 32	… proportional to concentration …, integer	0.919–0.932
41	AO	Fraction 33	… proportional to concentration …, integer	0.932–0.945
42	AP	Fraction 34	… proportional to concentration …, integer	0.945–0.958
43	AQ	Fraction 35	… proportional to concentration …, integer	0.958–0.971
44	AR	Fraction 36	… proportional to concentration …, integer	0.971–0.984
45	AS	Fraction 37	… proportional to concentration …, integer	0.984–0.998
46	AT	Fraction 38	… proportional to concentration …, integer	0.998–1.012
47	AU	Fraction 39	… proportional to concentration …, integer	1.012–1.025
48	AV	Fraction 40	… proportional to concentration …, integer	1.025–1.040
49	AW	Fraction 41	… proportional to concentration …, integer	1.040–1.054
50	AX	Fraction 42	… proportional to concentration …, integer	1.054–1.068

Column No	Excel column	Header	Value	Range, $cm^2V^{-1}s^{-1}$
51	AY	Fraction 43	… proportional to concentration …, integer	1.068–1.083
52	AZ	Fraction 44	… proportional to concentration …, integer	1.083–1.098
53	BA	Fraction 45	… proportional to concentration …, integer	1.098–1.113
54	BB	Fraction 46	… proportional to concentration …, integer	1.113–1.129
55	BC	Fraction 47	… proportional to concentration …, integer	1.129–1.144
56	BD	Fraction 48	… proportional to concentration …, integer	1.144–1.160
57	BE	Fraction 49	… proportional to concentration …, integer	1.160–1.176
58	BF	Fraction 50	… proportional to concentration …, integer	1.176–1.192
59	BG	Fraction 51	… proportional to concentration …, integer	1.192–1.209
60	BH	Fraction 52	… proportional to concentration …, integer	1.209–1.225
61	BI	Fraction 53	… proportional to concentration …, integer	1.225–1.242
62	BJ	Fraction 54	… proportional to concentration …, integer	1.242–1.259
63	BK	Fraction 55	… proportional to concentration …, integer	1.259–1.277
64	BL	Fraction 56	… proportional to concentration …, integer	1.277–1.294
65	BM	Fraction 57	… proportional to concentration …, integer	1.294–1.312
66	BN	Fraction 58	… proportional to concentration …, integer	1.312–1.330
67	BO	Fraction 59	… proportional to concentration …, integer	1.330–1.349
68	BP	Fraction 60	… proportional to concentration …, integer	1.349–1.367
69	BQ	Fraction 61	… proportional to concentration …, integer	1.367–1.386
70	BR	Fraction 62	… proportional to concentration …, integer	1.386–1.405
71	BS	Fraction 63	… proportional to concentration …, integer	1.405–1.425
72	BT	Fraction 64	… proportional to concentration …, integer	1.425–1.444
73	BU	Fraction 65	… proportional to concentration …, integer	1.444–1.464
74	BV	Fraction 66	… proportional to concentration …, integer	1.464–1.484
75	BW	Fraction 67	… proportional to concentration …, integer	1.484–1.505
76	BX	Fraction 68	… proportional to concentration …, integer	1.505–1.526
77	BY	Fraction 69	… proportional to concentration …, integer	1.526–1.547
78	BZ	Fraction 70	… proportional to concentration …, integer	1.547–1.568
79	CA	Fraction 71	… proportional to concentration …, integer	1.568–1.590
80	CB	Fraction 72	… proportional to concentration …, integer	1.590–1.611
81	CC	Fraction 73	… proportional to concentration …, integer	1.611–1.634
82	CD	Fraction 74	… proportional to concentration …, integer	1.634–1.656
83	CE	Fraction 75	… proportional to concentration …, integer	1.656–1.679
84	CF	Fraction 76	… proportional to concentration …, integer	1.679–1.702
85	CG	Fraction 77	… proportional to concentration …, integer	1.702–1.726
86	CH	Fraction 78	… proportional to concentration …, integer	1.726–1.749
87	CI	Fraction 79	… proportional to concentration …, integer	1.749–1.774
88	CJ	Fraction 80	… proportional to concentration …, integer	1.774–1.798
89	CK	Fraction 81	… proportional to concentration …, integer	1.798–1.823
90	CL	Fraction 82	… proportional to concentration …, integer	1.823–1.848
91	CM	Fraction 83	… proportional to concentration …, integer	1.848–1.873
92	CN	Fraction 84	… proportional to concentration …, integer	1.873–1.899
93	CO	Fraction 85	… proportional to concentration …, integer	1.899–1.926
94	CP	Fraction 86	… proportional to concentration …, integer	1.926–1.952
95	CQ	Fraction 87	… proportional to concentration …, integer	1.952–1.979
96	CR	Fraction 88	… proportional to concentration …, integer	1.979–2.006
97	CS	Fraction 89	… proportional to concentration …, integer	2.006–2.034
98	CT	Fraction 90	… proportional to concentration …, integer	2.034–2.062
99	CU	Fraction 91	… proportional to concentration …, integer	2.062–2.090
100	CV	Fraction 92	… proportional to concentration …, integer	2.090–2.119
101	CW	Fraction 93	… proportional to concentration …, integer	2.119–2.148
102	CX	Fraction 94	… proportional to concentration …, integer	2.148–2.178
103	CY	Fraction 95	… proportional to concentration …, integer	2.178–2.208

Column No	Excel column	Header	Value	Range, $cm^2V^{-1}s^{-1}$
104	CZ	Fraction 96	… proportional to concentration …, integer	2.208–2.239
105	DA	Fraction 97	… proportional to concentration …, integer	2.239–2.269
106	DB	Fraction 98	… proportional to concentration …, integer	2.269–2.301
107	DC	Fraction 99	… proportional to concentration …, integer	2.301–2.333
108	DD	Fraction 100	… proportional to concentration …, integer	2.333–2.365
109	DE	Fraction 101	… proportional to concentration …, integer	2.365–2.397
110	DF	Fraction 102	… proportional to concentration …, integer	2.397–2.430
111	DG	Fraction 103	… proportional to concentration …, integer	2.430–2.464
112	DH	Fraction 104	… proportional to concentration …, integer	2.464–2.498
113	DI	Fraction 105	… proportional to concentration …, integer	2.498–2.532
114	DJ	Fraction 106	… proportional to concentration …, integer	2.532–2.567
115	DK	Fraction 107	… proportional to concentration …, integer	2.567–2.603
116	DL	Fraction 108	… proportional to concentration …, integer	2.603–2.639
117	DM	Fraction 109	… proportional to concentration …, integer	2.639–2.675
118	DN	Fraction 110	… proportional to concentration …, integer	2.675–2.712
119	DO	Fraction 111	… proportional to concentration …, integer	2.712–2.749
120	DP	Fraction 112	… proportional to concentration …, integer	2.749–2.787
121	DQ	Fraction 113	… proportional to concentration …, integer	2.787–2.826
122	DR	Fraction 114	… proportional to concentration …, integer	2.826–2.844
123	DS	Comments	Comments in form of free text	

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