TARTU ÜLIKOOLI TOIMETISED
ACTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS
Alustatud 1893.a. VIHIK 947

# AIR IONS AND ELECTRICAL AEROSOL ANALYSIS

TARTU 1992

# MEASUREMENT OF AIR ION MOBILITY SPECTRA IN A WIDE RANGE

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The main purpose of this research was to obtain information about the mobility spectrum of air ions in indoor (laboratory) conditions. The article also deals with the testing of a relatively modern air ion spectrometer.

A ten-channel air ion spectrometer *UT-7914* was used for the measurements, a short description of the device is provided in [1]. The general design of *UT-7914* is quite similar to that of its prototype [2]. The main differences between the new spectrometer and the prototype are the reduced number of channels, the use of individual smallsize electrometers [3] for each channel instead of commutated electrometers, the control unit built of modern microchips, and the use of a unit of analogous indication of the signals from separate channels. The spectrometer has two aspiration measuring capacitors with divided effective capacitance. Thus there are 10 limiting mobilities with a logarithmically uniform distribution: 0.00048; 0.001; 0.0022; 0.0048; 0.01; 0.022; 0.048; 0.1; 0.22; 0.48 $cm^2/(V \cdot s)$.

For the computation of the mobility spectra H. Tammet has written programs for *NAIRI* computers on the basis of the piecewise linear spectrum model [4]. The present paper employs the program yielding the so-called λ-spectrum which is composed of 9 values of the conductivity function $\lambda(k)$ for the above mobility values $k$ = 0.00048; 0.001; 0.0022; 0.0048 etc. up to 0.22 $cm^2/(V \cdot s)$, and of the concentration of small air ions which have conventionally been given the mobility of 1 $cm^2/(V \cdot s)$. The values of the conductivity function at $k$ = = 0.48 $cm^2/(V \cdot s)$ are a priori taken to be zero. The program, alongside with the values of spectra, also yields the respective estimates of random errors.

The spectra were measured during 6 months from November 1981 to May 1982, as a rule, the measurements were conducted on weekdays from 17:00 to 18:00 (Moscow time). The measurements were carried out in laboratory without special sources of air ions and aerosols. One person servicing the spectrometer was in the room during the recording of spectra. The ventilation window was closed. In the whole measurement



period 630 negative and 665 positive air ion spectra were obtained. Before the calculation of average values the data were checked and in two cases some parts of it were not used: 1) if the computer issued a special symbol indicating the inexactness of the computation due to strongly anomalous data; 2) if the negative values of the spectra (in principle impossible) in their absolute values at least two times exceeded the estimate of the mean square error in the same fraction. In the first case the whole spectrum was rejected, in the second case the anomalous value and two neighbouring values on the right and on the left were rejected. The latter rule is based on special mathematical experiments which show that the deviance of the signal in one spectrometer channel causes error in several neighbouring fractions of the spectrum. The rejected values of the spectra were distributed roughly uniformly between the two above criteria.

The above rejection procedure left 4172 values, i.e. the average of 417 spectra for negative air ions, and 4805 values, i.e. the average of 480 spectra for positive ions. The averaged λ-spectrum for the whole measurement period is presented in Table 1 and Fig. 1.

Table 1

Air ion spectra in laboratory conditions

| Mobility $k$ $cm^2/(V \cdot s)$ | Values of the spectral function $\lambda(k)$: $e/cm^3$ | |
|---|---|---|
| | Negative air ions | Positive air ions |
| 0.00048 | 1005 | 1534 |
| 0.001 | 1522 | 1927 |
| 0.0022 | 397 | 438 |
| 0.0048 | 287 | 376 |
| 0.01 | 120 | 239 |
| 0.022 | 15 | 120 |
| 0.048 | 28 | -1 |
| 0.1 | -1 | 4 |
| 0.22 | 1 | 1 |
| 1 | 181 | 196 |

The resulting spectrum demonstrates that the maximum value of the spectral function is about $10^{-3}$ $cm^2/(V \cdot s)$ and that ions are practically absent in the mobility range from 0.05 $cm^2/(V \cdot s)$ before small ions.

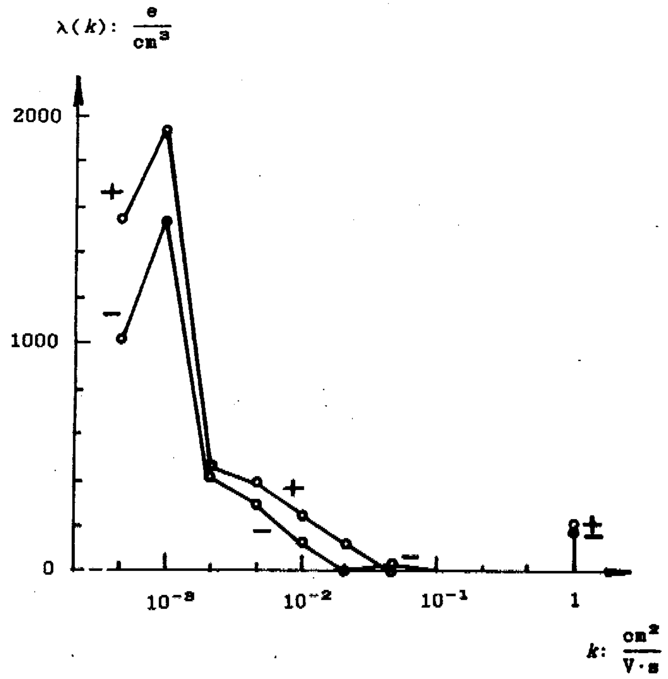


Fig. 1. Air ion mobility spectrum in laboratory conditions.

The spectral distribution of small air ions has not been specially studied in the present paper, however, according to existing data, small air ions are located approximately in the range from 0.5 to 2.5 $cm^2/(V \cdot s)$ [5, 6]. Thus, the mobility spectrum has a large gap approximately in the range from 0.05 to 0.5 $cm^2/(V \cdot s)$.

The a priori zeroing of the spectral function at $k = 0.48$ $cm^2/(V \cdot s)$ turned out to be justified: in the opposite case there would have been a significant value of the function at $k = 0.22$ $cm^2/(V \cdot s)$. The fact that almost all papers on air ion spectra published up to now do not show such a gap, can probably be explained by low resolution of the equipment and by significant measurement errors. The gap can be explained by the diffusion charging model of intermediate and large air ions, considering the ultra-low probability of the appearance of charged particles in the range of radii approximately from 1 to 3 nm (which correspond to the mobility range from 0.05 to 0.5 $cm^2/(V \cdot s)$) [7].



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Translated from:

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