9. DIURNAL VARIATIONS OF AIR ION MOBILITY CLASSES

9.1. Concentration of small air ions

The median concentration of small ions showed a slight difference considering the cold and the warm season. Examining the average diurnal variations of small ion concentration calculated for individual months, contrasts became apparent. The concentration of small ions had some considerable diurnal variation only in the warm season when the soil was unfrozen (see Figure 37). The diurnal variation was weakly expressed when the soil was wet and/or frozen. The average diurnal variation of negative small ions was close to that of positive ions; the ratio of positive to negative ion concentration (coefficient of unipolarity) was 1.11 and 1.15 in the warm and cold season, respectively.

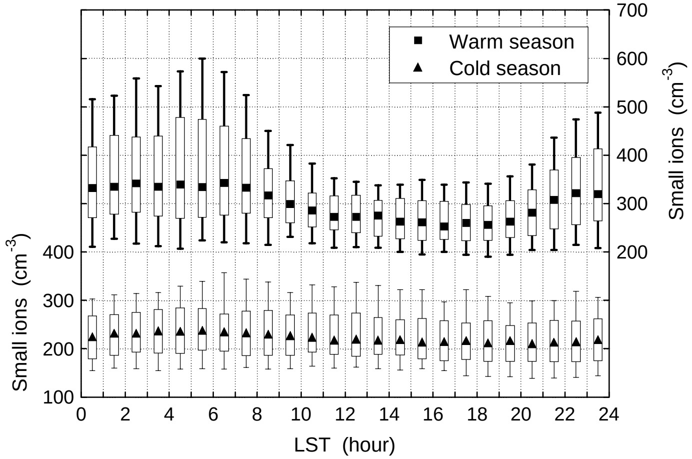

Figure 37. Average diurnal variation of the concentration of small positive ions (mobility 0.5–3.14 cm^{2}V^{-1}s^{-1}) in the warm season (September 1993 and May – September 1994) and in the cold season (November 1993 – April 1994). Statistics: median, box (25% and 75%) and whiskers (10% and 90% quantiles).

In the warm season, the concentration of small ions has the average diurnal variation of a single wave shape with the maximum in the nighttime and the minimum in the afternoon. The highest concentrations were recorded in fine weather conditions during anticyclones in July and August. The absolute maximum of small ions recorded on August 26 was 996 cm^{-3} for negative ions and 1176 cm^{-3} for positive ions, both in the early morning hours at 8–9 LST (Figure 38). The cause of the high concentrations was probably the accumulation of radon near the ground during nocturnal calms. Daytime minimum values of about 240 cm^{-3} for negative ions and 270 cm^{-3} for positive ions were close to the background concentrations. The absolute maxima were recorded at the end of a 3-day period of very weak winds at the daytime and calm in the nighttime (Figure 38).

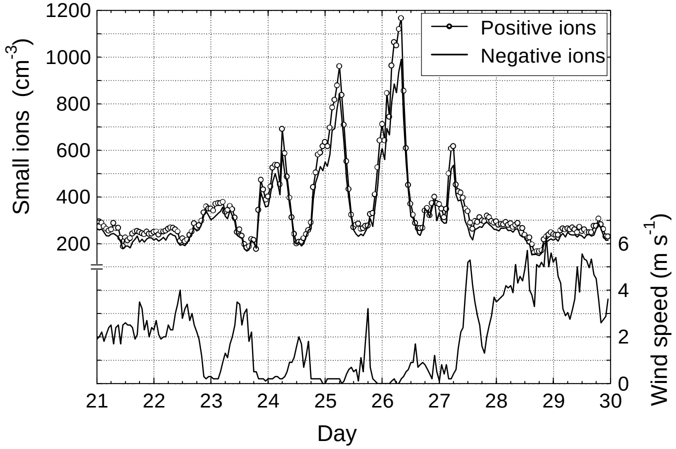

Figure 38. Diurnal variation in the concentration of small ions (0.5–3.14 cm^{2}V^{-1}s^{-1}) and wind speed from August 21 to August 30, 1994.

All the months with a considerable average diurnal variation in small ion concentration (from May to September, except June) were also characterized by a significant diurnal variation of wind speed (also air temperature and relative humidity) and by very low wind or calm at the nighttime. The average diurnal variation of small ions distinctly varied in the same phase as the changes in relative humidity and in the opposite phase to air temperature and wind speed. In July when all these quantities had a regular diurnal variation of large extent (drought period), the correlation coefficients of the small ion hourly average concentrations with air temperature, relative humidity and wind speed were –58%, 59% and –59%, respectively. The known effect of radon on the ionization rate of the air controlled by the convective and turbulent exchange of air near the ground played a key role for the observed correlations. The average diurnal variation in the concentration of aerosol particles in the Aitken mode range of 22–79 nm (followed by the heavy large ion concentration) was nearly parallel to that of small ions. The relatively low percentage of nocturnal calms in June was obviously the main cause of the low average diurnal variation of small ion concentration.

In the cold season, the diurnal variation of the median concentration of small ions was very weak, the amplitude of about 30 cm^{-3} (Figure 37). The maximum of negative ions was about 210 cm^{-3} (positive ions 240 cm^{-3}) at 5–6 LST and minimum 180 cm^{-3} (210 cm^{-3}) at about 20 LST. The average diurnal variation of small ions showed an opposite correlation with that of heavy large ions (see Figure 43a) and was therefore probably caused by the variation in the aerosol particle content in the air. The possible impact of radon on the concentration of small ions was studied during nocturnal calms in winter. Sometimes, the enhancement of small ions by about 100–200 cm^{-3} was observed, but most of them correlated negatively with the heavy large ion concentration.

The recent measurements at Tahkuse in August and September 1998 showed a clear diurnal variation of radon concentration in fine weather: from about 2–3 Bq m^{-3} in the afternoon up to 25 Bq m^{-3} in the early morning hours during calms. On other days the activity concentration of radon was in the range of about 4–6 Bq m^{-3}. The concentration of small ions was found to be dependent on both the concentrations of radon and aerosol particles (mainly of diameter 50–300 nm). The diurnal variation in the radon concentration depending on the stability of boundary layer air is well known [*Porstendörfer*, 1994; *Raunemaa et al.,* 1996; *Kataoka et al*., 1998]. The development of a ionization profile (ion concentration at different heights below 2 m) during quiet summer nights at Uppsala was studied by *Norinder and Siksna* [1952].

The diurnal variation in small ions at Tahkuse in 1985–1986 had a small secondary afternoon peak, especially in autumn [*Hõrrak et al.*, 1988b]. The present measurements showed that the secondary afternoon peak of small ions (in October) correlated oppositely with the concentration of heavy large ions.

Dhanorkar and Kamra [1993b] have reported the average diurnal variation of small ions at a height of 1 m above the ground at a tropical land station in Pune, India, in 1990–1991. The concentration minima in the afternoon of about 200–400 cm^{-3} were comparable considering all the seasons, the maxima in the early morning hours varied in the range of 1000–5000 cm^{-3}. The measurements of air conductivity at Helsinki-Vantaa Airport, Finland, in 1977–1986 [*Tuomi,* 1989] and at Marsta Observatory, Sweden, in 1993–1998 [*Israelsson and Tammet*, 2001] showed higher amplitudes of the average diurnal variation (with a maximum in the nighttime) in summer than in winter. The average conductivity at Helsinki-Vantaa Airport was about 40% higher and at Marsta Observatory 7 times higher than at Tahkuse. The differences could originate from different heights of measurement points and from different soil properties that support the radon exhalation. The measurements in the center of Athens for 1968–1980 [*Retalis et al.*, 1991] resulted in a double oscillation diurnal variation in conductivity, and the average conductivity was about 2 times lower than at Tahkuse. The origin of these differences obviously lies in the differences in urban and rural environment.

Detailed analyzes of the narrow mobility fractions of small ions (0.5–3.14 cm^{2}V^{-1}s^{-1}) showed that it is rational to classify small ions into two groups, called small and big cluster ions, respectively. These groups showed different shape of the average diurnal variation in the concentration. Negative small ions with the natural mean mobility and standard deviation of 1.53 ±0.10 cm^{2}V^{-1}s^{-1} (positive ions of 1.36 ±0.06 cm^{2}V^{-1}s^{-1}) were classified into groups with the boundary at 1.3 cm^{2}V^{-1}s^{-1} (1.0 cm^{2}V^{-1}s^{-1}).

In the warm season the average diurnal variation in small ion concentration was mainly caused by small cluster ions (Figure 39). The average diurnal variation of big cluster ions was week in general, and showed different behavior considering different months. For example, during the first decade of September 1993, the concentration of big cluster ions of negative polarity showed a regular diurnal variation (nearly opposite to that of small cluster ions) with the maximum of the median concentration at the daytime at about 15 LST and the minimum in the early morning hours at 4 LST. The diurnal variation of positive big cluster ions was less pronounced. Also in June, the median concentrations of small and big cluster ions exhibited a moderate nearly opposite diurnal variations, and therefore the variation in the total concentration of small ions disappeared. The minimum of the median concentration of big cluster ions in June was also recorded in the early morning at 4 LST.

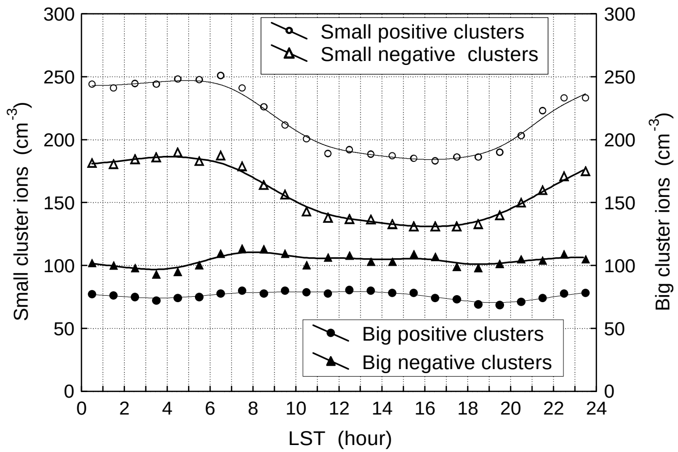

Figure 39. Diurnal variation in the median concentration of positive and negative small cluster ions and big cluster ions in the warm season (Sept. 1993, May – Sept. 1994).

In July the median concentrations of small cluster ions of both polarities showed the diurnal variation of high amplitude of about 200 cm^{-3}. Nevertheless, the median concentrations of big cluster ions were relatively steady of about 100 cm^{-3}, showing a little variation (about 30–40 cm^{-3}) of the similar shape with the average diurnal variation of small cluster ions. The enhancement of the concentration of big cluster ions by 50–100 cm^{-3} was recorded during the nocturnal calms when the concentration of small cluster ions rises above about

300 cm^{-3}, but no clear correlation between the absolute values was noticed.

Considering days with the bursts of intermediate ions in the warm season, the average diurnal variation in the concentration of small cluster ions showed a common single oscillation, but the big cluster ions showed a double oscillation: one maximum recorded at midnight and the secondary maximum at about noon. The minimum in early morning hours at 5 LST coincides with the air temperature and absolute humidity minima and the relative humidity maximum; the secondary minimum was recorded at 19 LST.

In the cold season, the general shape of the average diurnal variation in small cluster ions was similar to that of the total concentration of small ions in Figure 37. The concentration of big cluster ions was nearly constant at about 50 cm^{-3}. During the bursts of intermediate ions, the big negative cluster ions showed a peak median concentration of about 100 cm^{-3} and positive cluster ions of 80 cm^{-3} at noontime.

The variation in the proportion of small and large cluster ion concentration during the diurnal cycle leads to the diurnal variation in the mean mobility of small ions. The different behavior of cluster ions above 1 cm^{2}V^{-1}s^{-1} (called molions) and of the total concentration of small ions in the urban atmosphere in Tartu, Estonia, during 1951 and 1960–1963 was discussed also by *Reinet* [1958], *Marran* [1958] and *Prüller* [1970].

9.2. Concentration of intermediate ions

The average diurnal variation in the concentration of intermediate ions (mobility 0.034–0.50 cm^2 V^{-1} s^{-1}; diameter 1.6–7.4 nm) calculated for the whole measurement period had one peak value at about the local noon [*Hõrrak et al.*, 1998b]. The median concentrations of positive and negative ions were quite steady (about 40–50 cm^{-3}). Considering only days with the bursts of intermediate ions more than 100 cm^{-3}, the diurnal variation in the median concentration also became evident (see Figure 40). The median concentration (also higher quantiles) of negative intermediate ions had a higher amplitude of diurnal variation; the maximum at noon was 224 cm^{-3} compared to that of positive ions of 186 cm^{-3}. The enhanced median concentrations recorded from 9 to 18 LST are in accordance with a typical duration of bursts from 6 to 9 hours.

During the evolution of aerosol ion mobility spectra, the median concentrations of narrow mobility fractions of 0.034–0.32 cm^{2}V^{-1}s^{-1} reached peak values at different times at local noontime. The time of the peak value is the later the lower is the mobility of the fraction.

The average diurnal variation presented in Figure 40 was characteristic to the anticyclonic weather, and was probably initiated by photochemical nucleation process that started at sunrise and achieved the maximum intensity at noon. The generation of intermediate ions followed after sunrise, with the delay of about 2–3 hours, during the stage of quick development of the boundary layer. Thus, the formation of intermediate ions was closely related to the boundary layer meteorology. The median concentration of intermediate ions was correlated negatively with the median relative humidity and positively with the median air temperature and wind speed during diurnal cycle.

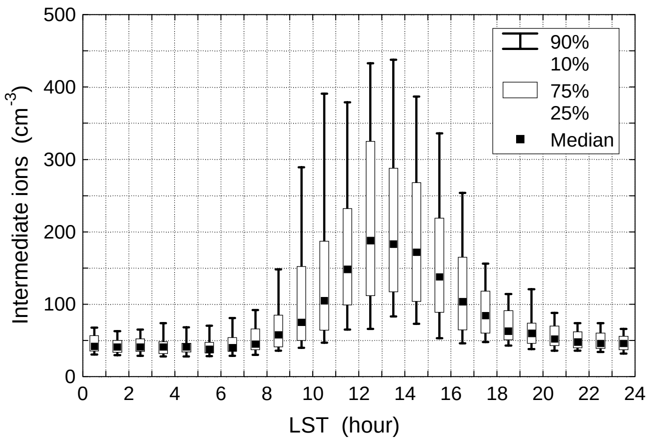

Figure 40. Average diurnal variation in the concentration of positive intermediate ions (mobility 0.034–0.5 cm^{2}V^{-1}s^{-1}; diameter 1.6–7.4 nm) considering days with the bursts of intermediate ions. September 1993 – October 1994. Statistics: median, box (25% and 75%) and whiskers (10% and 90% quantiles).

The bursts occurred on sunny days, when the solar radiation was relatively intense, the temperature difference between early morning and afternoon was large, and relative humidity decreased clearly from morning to noon. The main differences between the meteorological parameters during the burst days and non-burst days are presented in Table 15.

Table 15. Diurnal variations of the medians of meteorological parameters recorded during burst /non-burst days. Sept. 1–Nov. 16, 1993 and Feb. 25–Oct. 27, 1994.

Time LST, hour	Temperature °C	Rel. humidity %	Abs. humidity g m^{-3}	Wind speed m s^{-1}
4–5	1.3/6.5	94/94	4.9/6.8	1.1/1.4
14–15	12.1/13.5	43/66	4.9/7.7	3.0/2.6

It was characteristic to bursts, especially to very high bursts, that the rise in concentration was more abrupt than the decrease to background concentration. Sometimes very sharp bursts were recorded where the peak concentration was reached within 1 hour (the time resolution of data was 1 hour). Some of them showed a clear correlation with the passage of fronts. For example, on April 30, 1994 at 10–11 LST the concentration of intermediate ions increased suddenly to about 860 cm^{-3}, and then gradually decreased to background concentration of about 40 cm^{-3} during the following 5–6 hours.

Observations of intermediate ions at Tahkuse showed the behavior similar to that of nanometer aerosol particles [*Weber et al.*, 1995, 1997, *McGovern et al.*, 1996a, b]. The nanoparticle formation events were detected at Hyytiälä SMEAR station in the Southern Finland [*Mäkelä et al*., 1997, 2000a; *Kulmala et al*., 1998] after a change from the stable stratification of atmosphere at night to mixing in the morning hours at 8–9, with the concentration maxima around noon. The nanoparticles with the measured sizes of about 3 nm grew during 6–12 hours, reaching the Aitken size range of 60–70 nm in the evening.

The diurnal variation of intermediate ion concentration of different character was observed at a tropical land station by *Dhanorkar and Kamra* [1992, 1993b]. In transition and monsoon periods, the concentration of intermediate ions (critical mobility 0.02 $cm^2V^{-1}s^{-1}$) at a height of 1 m above the ground showed a maximum after sunrise between 6 and 9 LT, and afterwards with a delay of about 1–3 hours after sunrise, it suddenly dropped. In winter and summer the concentration of intermediate ions, as well as that of large ions, increased steadily thorough the night and decreased after sunrise.

9.3. Concentration of light large ions

The light large ions (mobility 0.0042–0.034 $cm^2V^{-1}s^{-1}$; diameter 7.4–22 nm) varied differently from intermediate ions; their maximum concentrations were shifted to somewhat later hours. In the case of the bursts of intermediate ions an evolution process was observed in the range of intermediate and light large ions: the spectral peak shifted from the lower diameters to the upper ones [*Hõrrak et. al.,* 1998b]. Oppositely to the intermediate ions, no significant difference between negative and positive light large ion concentrations was observed.

To distinguish the possible influence of photochemical nucleation bursts on the diurnal variation of light large ions from other mechanisms of gas-to-particle conversion, two different situations have been examined. A day is classified as a "burst day" if the concentration of intermediate ions (diameter 1.6–7.4 nm) exceeds 100 cm^{-3} during at least 2 hours; the opposite case is called a "non-burst day". The contrast of average diurnal variations in Figure 41 is apparent. A lot of new particles, produced by the nucleation bursts, grew by the condensation and coagulation, showing maxima in the size range of light large ions of 7.4–22 nm in the afternoon. The rate of particle production by other mechanisms was weaker and the maximum concentrations were shifted to later hours in the evening. Stable atmosphere in the evening could favor the process.

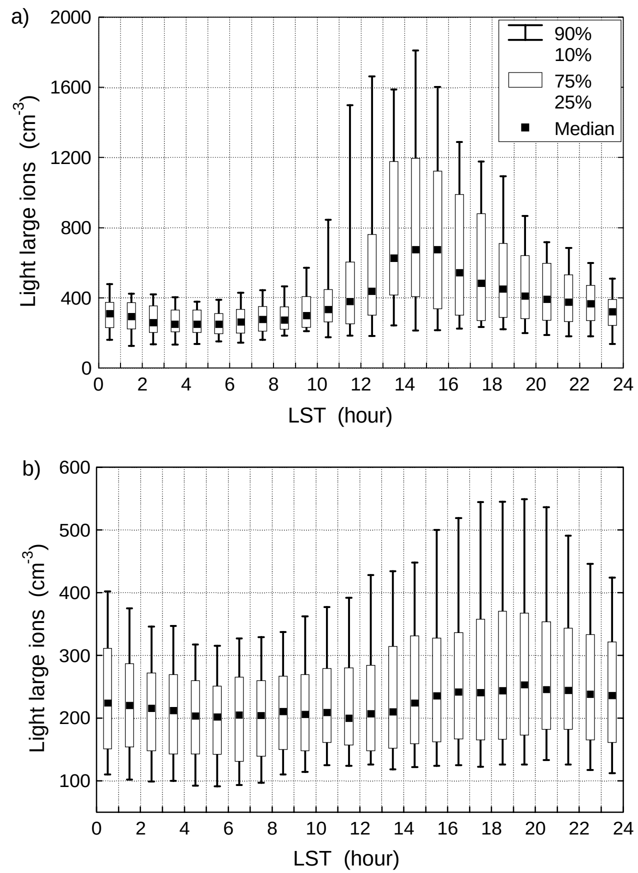

Figure 41. Average diurnal variation in the concentration of positive light large ions (0.0042–0.034 $cm^2V^{-1}s^{-1}$; 7.4–22 nm): a) considering days with the bursts of intermediate ions, b) without bursts. September 1993 – October 1994. Statistics: median, box (25% and 75%) and whiskers (10% and 90% quantiles).

The decrease in the median concentration of light large ions (as well as 75% and 90% quantile) during the nighttime was characteristic to all the months. It was probably due to the coagulation and growth by condensation of these particles into large ones; also removal from the atmosphere by deposition could be significant [*Hoppel et al*., 1990]. In the wintertime the minimum appeared at 6 LST, but in other months a secondary minimum was recorded at noontime (especially considering non-burst days). The minimum at noon (about 200 cm^{-3}) became dominant in July and August. In contrast to that, the average concentration in the afternoon displayed a high maximum of about 850 cm^{-3} in

May. The high bursts of intermediate ions in May and the absence of them in July and August could explain the contrast in the light large ion concentrations.

Ulevičius et al. [1991] have measured aerosol particle size spectra in the range of 20–500 nm at Aisetas background station in Lithuania (100 km NE from Vilnius) during summers in 1986–1987. Three types of spectra were distinguished according to the directions of long-range transport: across the Baltic Sea, from the unpolluted northern regions, and from the industrial regions of Western Europe. All the cases showed a distinct diurnal variation in the concentration of ultrafine particles of a diameter of about 30 nm during the anticyclonic weather. The first had a maximum in the afternoon, the second in the evening; the third type was a combination from the first two. No clearly expressed diurnal variations were registered during cyclonic weather.

9.4. Concentration of heavy large air ions

The average diurnal variation in the concentration of heavy large ions (mobility 0.00041–0.0042 $cm^2V^{-1}s^{-1}$; diameter 22–79 nm) was very week, in general. Considering the cold and warm season separately, the average diurnal variations displayed a different behavior (Figure 42). In the cold season, the minimum of the median concentration of about 1000 cm^{-3} was recorded in the early morning hours at 6 LST, and the maximum of 1420 cm^{-3} in the late evening at 20–21 LST. In the warm season, the early morning hours at 6–7 LST exhibited the concentration maximum of about 1440 cm^{-3}; the minimum of 1170 cm^{-3} was recorded in the afternoon at 14–15 LST. The amplitude of the diurnal variation in the median concentration was modest (about 300–400 cm^{-3}) compared with the overall statistical average and the standard deviation of 1190 ±700 cm^{-3} and 1330 ±620 cm^{-3} for the cold and warm season, respectively. The diurnal variations of positive and negative heavy large ions were closely correlated.

In the warm season, the diurnal variation in the median concentration of heavy large ions depicted in Figure 42 was characteristic to all of the months from June to September (May was an exception, probably due to high bursts of intermediate ions). It was more clearly expressed in July 1994 in conditions of very hot and durable anticyclones. A peculiarity for these months was the relatively high amplitude of the diurnal variation in meteorological parameters, and weak wind or calm in the nighttime (see Table 16). The diurnal variation in the median concentration of heavy large ions correlated positively with the median relative humidity (correlation coefficient was 96%, critical coefficient at confidence 95% is about 40%) and oppositely with air temperature (–96%) and wind speed (–94%).

Table 16. Diurnal variations of the medians of meteorological parameters during the cold/warm season. Cold season: November – March; warm season: May – September.

Time LST, hour	Temperature °C	Rel. humidity %	Abs. humidity $g\ m^{-3}$	Wind speed $m\ s^{-1}$
5–6 /4–5	–5.0/8.8	92/94	3.1/8.0	2.4/0.5
14–15	–2.3/18.7	81/49	3.3/9.0	3.1/2.4

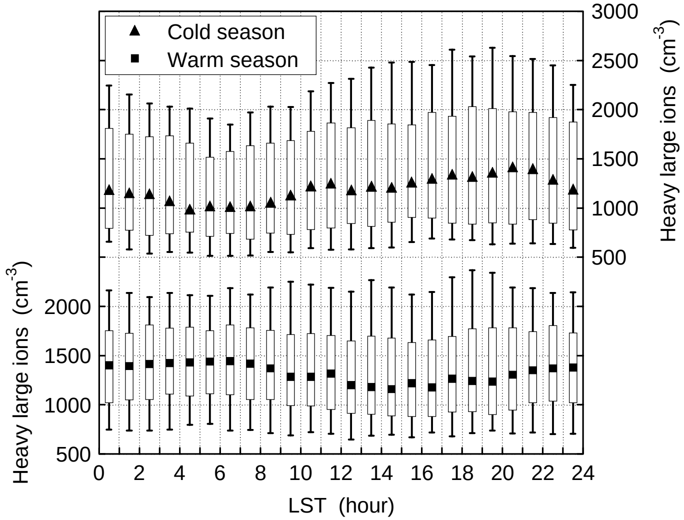

Figure 42. Average diurnal variation in the concentration of positive heavy large ions (0.00041–0.0042 $cm^2V^{-1}s^{-1}$; 22–79 nm) in the cold season (November – March) and in the warm season (May – September). Statistics: median, box (25% and 75%) and whiskers (10% and 90% quantiles).

In the warm season the diurnal variation in large ion concentration could be well explained by the changes in the stability of air close to the ground in the morning and by the accumulation of aerosol particles below nocturnal inversions. The formation of particles during the nighttime was probably due to the gas-to-particle conversion aided by radiolytic processes. The latter was expected because, in the warm season, the diurnal variation in the median concentration of heavy large ions in Figure 42 showed a similarity to that of small ions in Figure 37. The nearly parallel average diurnal variations of small and large ions were found also by *Arold and Matisen* [1992] and *Dhanorkar and Kamra* [1993b]. A simultaneous enhancement of small and heavy large ion concentrations during nighttime was sometimes recorded at Tahkuse. For example, in July, during the period of about two weeks the correlation coefficient between the concentrations of small and heavy large ions was 62% and 48% for positive and negative polarity, respectively.

The ability of ionizing radiation to produce beside small air ions also condensation nuclei aerosols (Aitken particles) in the presence of some trace gaseous species in the air is well-known (e.g. *Vohra et al*., 1970; *Hopke and Ramamurthi,* 1988; *Ramamurthi et. al*., 1993). The details of the process, concerning atmospheric aerosol production, are currently a point of issue.

Despite of the apparent regularity of the average diurnal variation of heavy large ion concentration in the cold season (Figure 42), we have to notice that it is long-term statistical average. Considering different months from November to March, the minima of the median concentrations were recorded in the early morning hours at about 5–7 LST; the maxima took place at different times in the evening. A secondary maximum around noon was recorded in February and March. Because of the high variability of the monthly median concentrations of heavy large ions in the cold season, a large database (about 3 months) was necessary to obtain a clear pattern of diurnal variations.

In winter the diurnal variation in the median concentration of heavy large ions was similar to that of light large ions. All the groups of aerosol ions (mobility 0.00041–0.29 $cm^2V^{-1}s^{-1}$; diameter 2.1–79 nm) showed the diurnal variation of a similar shape, if to exclude days with the bursts of intermediate ions. As the aerosol ions of both polarities showed the same regularities, only the average concentrations are shown in Figure 43.

The concentration of intermediate ions in Figure 43a showed a maximum before the heavy large ions reached the maximum in the evening. The decrease in the concentration during the nighttime was probably due to deposition, coagulation and growth of particles by condensation. The cause of the generation of particles, which started in the early morning, remained indistinct. In winter, the NO_2 correlated with the concentration of heavy large ions; the correlation coefficients were in the range of 54%–77% from November to February, and 41% in March. Probably the combustion processes influenced the average diurnal variation of large ions, as well as the entire group of aerosol ions, during the heating period. However, only a weak and roughly similar diurnal variation in the median concentration of NO_2 was found: the minimum of about 3.2 µg m^{-3} was at 5–6 LST and the maximum 4 µg m^{-3} at 21–22 LST.

The diurnal variations in the median concentrations of aerosol ion classes in the warm season (from May to September), excluding days with the bursts of intermediate ions are presented in Figure 43b. Comparing with the cold season, all the aerosol ion classes showed a different behavior. The amplitude of the diurnal variation in the intermediate ion concentration is very small, but the variation of the nanometer particles, which they represent, is many times larger. The bipolar charging probabilities for the existence of a single elementary charge (of one polarity) on the particles of the diameters of 2.1, 7.4, 22 and 79 nm are about 0.7%, 3.8%, 12% and 24%, respectively [*Reischl et al.*, 1996].

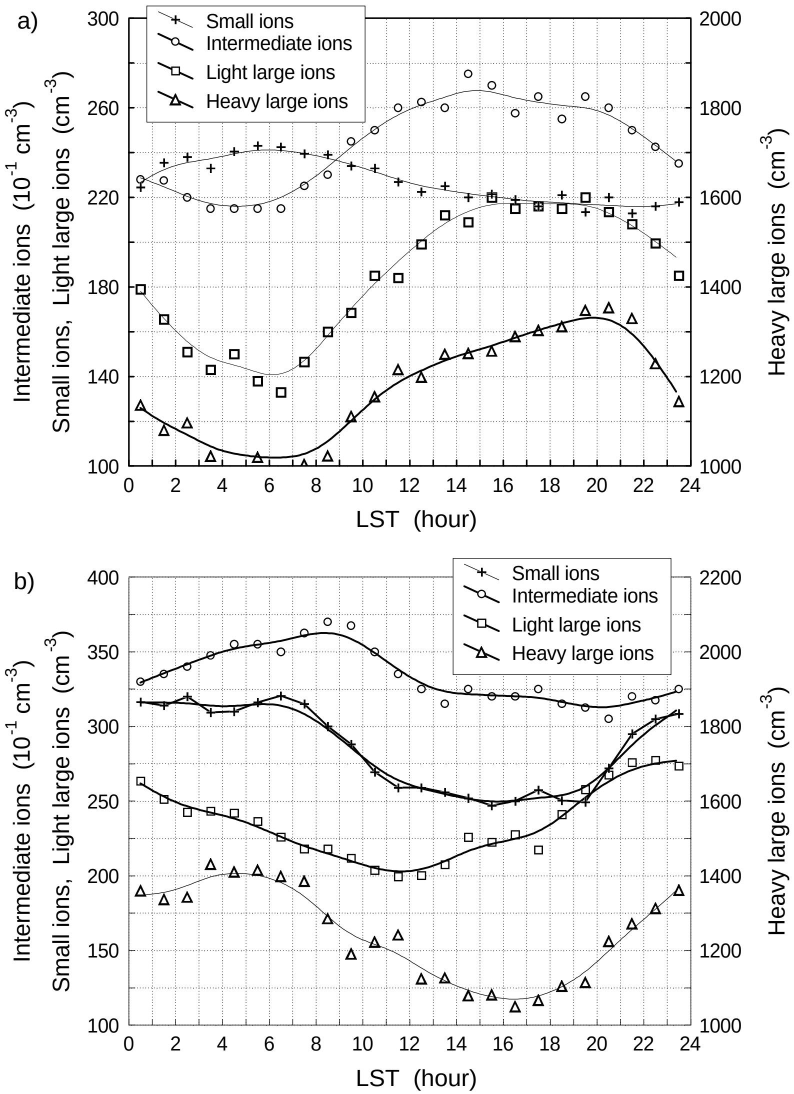

Figure 43. Diurnal variation in the median concentration of small positive ions (0.5–3.14 $cm^2V^{-1}s^{-1}$), intermediate ions (2.1–7.4 nm), light large ions (7.4–22 nm) and heavy large ions (22–79 nm): a) in the cold season (November – March), b) in the warm season (May – September), excluding days with the bursts of intermediate ions.

The diurnal variation in the median concentration of heavy large ions in the warm season is generally opposite to that of in the cold season. The average diurnal variation of meteorological parameters in the cold season was of low amplitude compared with the warm season (Table 16). We expect that the differences in the mixing of the boundary layer air and different processes of aerosol particle generation (combustion versus radiolytic processes) could explain the contrast of the average diurnal variations in heavy large ion concentration in the cold and warm seasons. Also, the influence of the local air pollution is more pronounced in winter, when the thickness of vertically mixed atmospheric boundary layer is about 300 m, compared to 1.5–2 km in summer.

Juozaitis et al. [1996] measured the continental aerosol particle size distributions in summer 1990 and winter 1992 at Aisetas station and in a suburb of Vilnius, Lithuania. The condensation of low-pressure vapors formed by the gas-phase chemical reactions was found to be the predominant mechanism of the growth of aerosol particles smaller than 120 nm through all the year. The particles smaller than 50 nm had a different growth rate in winter and summer, because of their different nature. In the cold season, a considerable amount of aerosol particles with diameters below 50 nm (about 60% of 20 nm) were hydrophobic, and obviously originated from combustion processes.

One particular problem that can be studied on the basis of the average diurnal variations is how the bursts of intermediate ions contribute to the heavy large ion concentration (charged Aitken particles) [*Hõrrak et al*., 2001]. It is rather complicated to draw reasonable conclusions when examining single burst events in a single measuring point (Eulerian experiment). In general, the disturbed region of air ion mobility spectra affected by the bursts of intermediate ions was extended up to about 34 nm. The gradual shift of the spectral peak beyond 22 nm was observed only sometimes. The advection of air masses, turbulent and convective mixing, and various processes that affect the Aitken particle concentration in the air [*Hidy*, 1984] can blur the effect.

A statistically weighty database of the bursts obtained for the warm season from May to September (57 days when the concentration exceed of 100 cm^{-3}) enables to study the influence of the bursts of intermediate ions on the heavy large ion concentration in more detail. The average diurnal variations in heavy large ion concentration during the days with the bursts of intermediate ions versus common (non-burst) situations are presented in Figure 44. Considering the non-burst days, the median concentration of intermediate ions was relatively steady of about 32–37 cm^{-3} (see Figure 43). The diurnal variations of the basic meteorological parameters are presented in Table 17.

Table 17. Diurnal variations of the medians of meteorological parameters recorded during burst /non-burst days in the warm season (Sept. 1993, May – Sept. 1994).

Time LST, hour	Temperature °C	Rel. humidity %	Abs. humidity g m^{-3}	Wind speed m s^{-1}
4–5	5.7/10.6	94/93	6.4/8.9	0.5/0.4
13–14 /14–15	18.8/19.3	43/56	6.5/10.3	2.6/2.1

Median wind speed maximums around 16 LST were 3.0 /2.2 m s^{-1}.

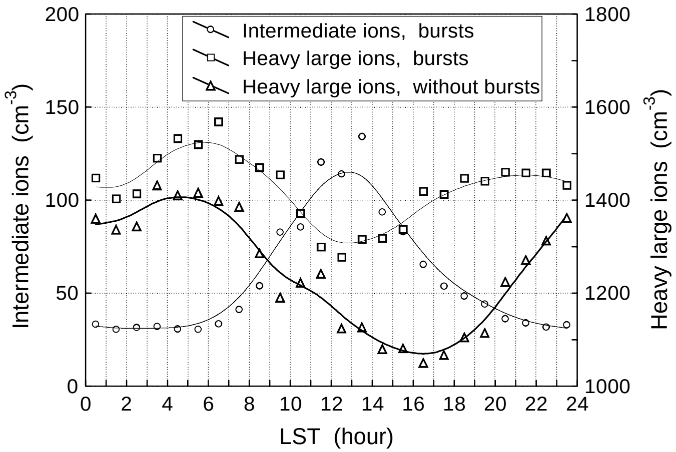

Figure 44. Diurnal variation in the median concentration of intermediate ions (mobility 0.034–0.29 cm^{2}V^{-1}s^{-1}; diameter 2.1–7.4 nm) and heavy large ions (0.00041–0.0042 cm^{2}V^{-1}s^{-1}; 22–79 nm) in the warm season, the burst events of intermediate ions versus common situation. Sept. 1993, May – Sept. 1994.

We assume that the average diurnal variation in the concentration of heavy large ions (charged Aitken particles) during the non-burst days was caused by the mixing of air close to the ground at daytime, and by the particle generation of different origin than the nucleation bursts. Considering the burst events, the relatively higher concentrations of charged Aitken particles in the afternoon was probably caused by the bursts of nanometer particles and the subsequent growth of particles by condensation and coagulation towards large sizes. The boundary layer mixing in the afternoon was likely comparable in both cases. Both cases showed an increase in the Aitken particle, as well as in small ion concentration during the nighttime probably due to radiolytic processes (initiated by ^{222}Rn, ^{220}Rn decay) favored in the conditions of nocturnal calms.

During the cold season, the background concentration of heavy large ions was rather variable and the number of burst events was not enough to draw statistically grounded conclusions about the contribution of the bursts of nanometer particles (intermediate ions) to the heavy large ion concentration.