SIMULTANEOUS DETECTION OF SMALL AIR-IONS AND α-PARRTICLES FROM Rn^{222} DECAY NEAR THE GROUND

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1. INTRODUCTION

Detection of small air-ions, both positive and negative, is of practical interest because these ions are natural constituents of the air near the ground (~ 500 *ion* cm^{-3} in the fair weather conditions). The knowledge about atomic processes in the atmosphere is crucial in microphysics approach to meteorological parameters as basic quantities of the phenomenological view to atmospheric physics. Particular interest is consideration of numerous mechanisms of the electricity separation. According to modern atmospheric electrostatics, generation of the ions and their evolution in the atmosphere are responsible for the origin of the Earth electric field [1].

Main mechanism of the air-ion production near the ground is collision ionization of air molecules by 5.5 *MeV* α-particles from Rn^{222} decay. Our aim in this work is detection of these α-particles (as a cause of the ion-pairs formation), and the ions (as the consequence), at the same time interval.

2. EXPERIMENTAL

We designed an instrument for simultaneous detection of: 5.5 *MeV* α-particles from Rn^{222} decay, and small air-ions (mobility $\approx 50\cdot 10^{-6}\ m^2V^{-1}s^{-1}$) predominantly single charged. Because the energies of the α-particles and of the ions are enormously different, specific methods of their detection have been used.

Nuclear track detector, namely the nitro-celluloid base of Kodak LR-115L film, sensitive to α-particles of energies below 4.5 *MeV*, was used in both long-term and short-term methods [2]. In the long-term method, the film is mounted bottom in a plastic 0.5 dm^3 cup. The cup is inversely positioned 30 *cm* under the ground (figure 1).

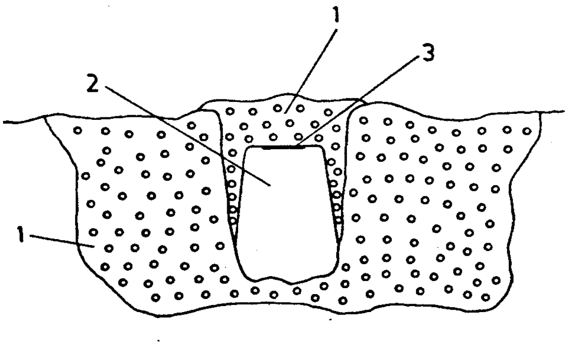

Figure 1a. A view of the long-term measuring place. Ground (1), plastic cup (2), and Kodak LR-115L track-detector (3).

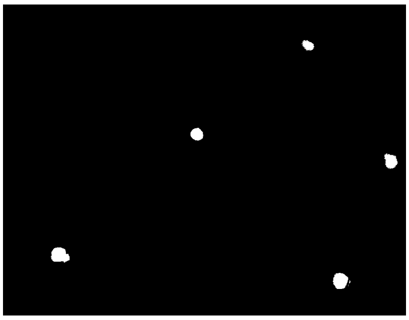

Figure 1b. Tracks of α-particles from Rn^{222} decay, in nitro-celluloid detector Kodak LR-115L.

In this method Rn^{222} accumulates in the cup during approximately one year. After chemical treatment of the film in such way exposed, number of nuclear tracks was determined using an optical microscope. The density of these tracks is proportional to the exhalation (i.e. diffusion rate) of Rn^{222} from the ground. We have measured the exhalation on several places in Serbia: Sokobanja ("atomic" spa), Sirogojno (Zlatibor mountains) and Belgrade (The Federal Hydrometeorological Institute). These results served us to choose the best place for our simultaneous measurements.

The same Kodak LR-115L track detector, (1) in figure 2, was used in the short-term method, but in housing, shown schematically below. In front of the detector is 7-8 μm aluminum foil (2) due to increase of the efficiency for α-particle detection. At list 10 m^3 of the air must flow trough the housing (3) and a glass filter (4) on the stainless steel greed (5). Radon and products of its decay accumulate in the filter during several ours.

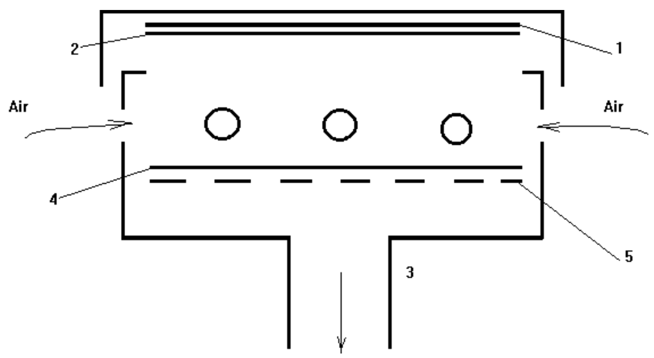

Figure 2. Scheme of the short-term α-particle detector.

After 24 hours exposition of the detector which is close (1 *cm*, approximately) to the filter with α-radioactive nuclides, chemical treatment of the detector applies, the same as in the long-term method.

Air-ion detection near the ground was performed using the Gerdian type cylindrical electrostatic condenser (figure 3). This method is described recently [3].

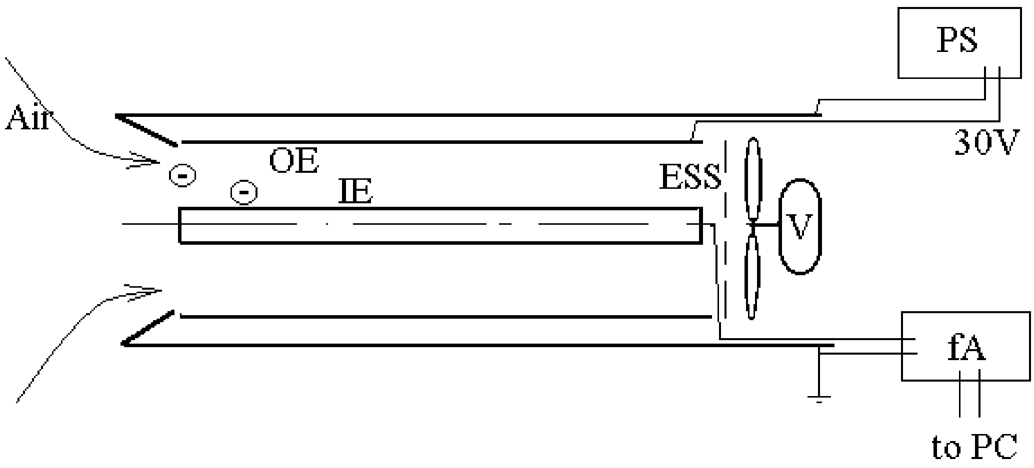

Figure 3. OE –outside electrode, IE –inside electrode, ESS –electrostatic shield, PS –power supply, V –fan, fA –femptoampermeter, PC –personal computer.

Detection of air-ions is possible by using their electrical properties. Potential difference of only 30 *V* between OE and IE is enough for total collection of small ions between them. Ions of the same sign as the outer electrode are repelled to the central electrode. Low mobility (massive or large) ions practically do not affect this measurement. The ion current is of the order of 10^{-15} *A* so, special care is needed in the construction and insulation, and also signal-to-noise ratio.

3. RESULTS AND DISCUSSION

We have measured Rn^{222} exhalation from the ground using the long-term method. We found that the most interesting place is Sokobanja "atomic" spa. Results of measurements close to three locations in the spa are as follows. (a) Old bathing-place: 990 *tracks per detector*; (b) New fountain: 694 *tracks per detector*, and (c) New bathing-place: 412 *tracks per detector*.

Statistical error in both, long-term and short-term method is determined by Poisson statistics.

According to our preliminary results of simultaneous detection of α-particles from Rn^{222} decay and small air-ions, at list 10 m^3 of the air must pass through the detector in short-term method.

Production of ozone is also an interesting phenomenon in Sokobanja. It is probable in correlation with radon and air-ions, but it is not under our consideration in this work.

These measurements are of interest for Sokobanja, and for other “atomic” spas in Serbia, as well. Although radioactive rays are generally dangerous, small dozens could be of benefit to human health (hormesis effect) [4].

ACKNOWLEDGEMENT

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REFERENCES:

1. Wahlin, *Atmospheric Electrostatics*, John Wiley & Sons Inc., New York, 1989.
2. R.L.Fletscher, P.B.Price, and R.M.Walker, *Nuclear Tracks in Solids*, University of California Press, 1975.
3. P.Kolarž, B.P.Marinković and D.M.Filipović, Applied Physics in Serbia, 2002, Belgrade, Book of Contributed Papers, p. 183-6.
4. H.Friedmann, *Nucl. Phys. News*, **7** (1997) 14.