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Project ARM
AEROSOL and RADIOACTIVITY METER

Background

Various integral parameters of aerosol and radioactivity have been discussed as the measures of environmental pollution. In case of aerosol the mass concentration and the number concentration have been mostly considered. An intermediate parameter called particle size concentration is proposed in the project as a compromize. The particle size concentration indicates the length of the chain composed of all particles in a volume unit. Unpolluted continental air contains about 1 km of particles in 1 m^3. The free air ionization rate is proposed as the integral measure of environmental radioactivity. All kinds of ionizing radiations are equally counted in this quantity. The life time of ions in free air is about one minute. The proper technique of measurement enables to use the physical averaging of the radioactivity over the trajectory of the air mass in the last minute. The typical value of free air ionization rate in unpolluted environment is about 15 microroentgen per hour.

The principles of a method of simultaneous measurement of aerosol particle size concentration and free air ionization rate are described in the appendix.

Applications

The instrument will have two independent outputs to indicate the particulate pollution of the air and radioactive pollution of the environment. The simplest application is the use of the instrument as an aerosol and radioactivity sensor in various environmental monitoring systems.

A most promising application is the use of the instrument as a personal monitor of environmental pollution.

Development

The measurement principle is successfully approved of in Main Geophysical Observatory, St. Petersburg (s. reference in the appendix). The key units of the instrument are two ion concentration sensors and the calculator to execute the nonlinear tranformation of directly measured ion concentrations to environmental pollution parameters. The ion concentration sensors should be inexpensive and reliable. A special requirement is low air flow rate. Suitable sensors could be elaborated using the technical ideas of the project AIM. Various calculator units can be used. An easy way is to use some standard computer equipped with a simple data acquisition unit. This method is favourable in case the autonomous recording of the data and expressive display of time variations etc. is required. The other way is the use of special data aquisition microprocessor or an analog calculator circuit. The choice is depending on the supposed application of the instrument.

Project AIM
AIR ION METER

Background

Several models of air ion meters (or air ion counters) have been designed in Tartu University during a long period. Fundamentals of the design are described in the book by H.Tammet "The Aspiration Method for the Determining of Air-Ion Spectra", Jerusalem, 1970. About 300 instruments have been manufactured and sold under individual contracts. They are all based on the classical technique of DC electrometric measurement. The alternative technique of modulated current measurement was proposed by Junod, Sänger and Thams in 1962. Improved versions of the modulation method have been analysed in the above mentioned book. However, the practical use of the new technique was hindered by the lack of efficient electronic components in earlier years. New attempts to introduce the modulation method have been successful. The first modern instrument designed in Tartu University for a special application is described in the appendix. Features of the new modulating air ion meter AIM-1 designed for commercial use are: two LCD displays simultaneously for + and - ions, resolution 20 ions/cm^3, size 20 * 15 * 8 cm, mass (with batteries) 1.8 kg, and no need in manual zero adjustment. New ideas were generated in the process of development and testing of AIM-1. They enable to reduce the costs of manufacturing, reduce the size of the instrument and simplify the process of measurement. Only display and two control switches will remain on the front panel: power on/off and polarity +/-.

Advantages

The modulating technique may be considered as a quick automatic zero correction. This enables to suppress the zero drift and avoid the manual zero control. The requirements to the electrostatic insulation are reduced in several orders of magnitude which gives the instrument high reliability even in humid environment and enables to reduce the manufacturing costs.

If compared with the PERISO Meteoline-2001 the advantages of AIM are enhanced reliability, low cost, small size and easy manipulation. If compared with TRANSJONIC T-100 the advantages of AIM are enchanced reliability and convinience of measurement.

Stage of development

The draft documentation for manufacturing of AIM-1 and principial physical and engineering ideas for AIM-2 are available. The development of AIM-2 is in standstill due to the economic situation. The moderate funds and 6-10 months time would be needed to complete the development and manufacture the first instrument.

Project IPSD
IDENTIFYIER OF PARTICLE SIZE DISTRIBUTION

Background

The output of a standard aerosol spectrometer is the multifraction presentation of the particle size distribution. In some applications the set of fraction concentrations is used only as a raw data for the identification of the model spectrum (log-normal, modified gamma etc). This is not a rational way to process information. The true raw data is the set of directly measured signals which is used in the instrument to estimate the fraction concentrations. Some amount of original measurement information is contained in covariation matrix of measurement errors and it is lost in the standard multifraction presentation of the data. The better way of data processing is to identify the model spectrum directly on the basis of the set of measured signals.

The problem is not easy. There is a lot of warning examples where the estimation of model parameters on the basis of the multifraction presentation leads to the unstable mathematical problems and ambiguos solutions. The estimation of model parameters on the basis of instrument signals is more complicated. However, the problem of the stability of the transformation can be solved using the technique of the model quality analysis, presented in the appendix. The problem of using the original instrument signals instead of the set of the fraction concentrations can be easily solved using the matrix technique elaborated and approved of in early stages of the EAS project.

Advantages

The number of parameters of a model spectrum is usually several times less than the number of fractions in a multifraction presentation. It follows that the number of simultaneous measurement channels can be essentially reduced if the multifraction presentation is avoided. Direct identification of the model spectrum and estimation of its parameters promises a considerable effect on the size of the instrument, technical reliability, instrument manufacturing expenses and convinience of measurement.

Probably, most of users of the aerosol instruments in the field of environmental air monitoring as well as in case of some other applications will prefer the output of an instrument in terms of model distribution even if the price of the instrument is the same as the price of a multifraction instrument. All kinds of distribution diagrams could be diplayed on the basis of the identified model distribution.

A specific feature of the new instrument will be the greatly enhanced role of the software in the performance of the instrument.

The plan of development

The project seems very raw at a first glance. No real instrument or practical experience are existing. However, the tools for research and development are well prepared.

The only possible efficient way of development is to optimize the instrument structure and parameters using a computer simulation of the spectrometer. The submodels elaborated and approved of in the early stages of the development of EAS can be used as the components of the simulator.

The estimated period of time needed to create a perfect simulator is 9-12 months. In the next stage, a few months are needed to elaborate the principial solutions, and less than one year for the design and manufacturing of the first instrument. The first version of the basic software will be ready at the same time because most of the software modules have been tested already in the simulator.

Project NANO
IMPROVEMENT OF THE CALIBRATION OF DMA 1/40 IN NEAR-NANOMETER SIZE RANGE

Problem

The particles of size about one nanometer are the new subject of aerosol physics but the traditional subject of air ion physics. Therefore the specialists in the field of air ion and cluster physics are well aware of a drawback in the calibration of DMA1/40. The instrument diplays the size of cluster air ions about 1.0 nm. However, the true size of these ions is about 0.7 nm (average size of atmospheric negative cluster ions is 0.67 nm and of positive cluster ions 0.71 nm).

The plan of development

The results of simultaneous measurements of mass and mobility of cluster ions should be used to derive the improved size calibration function for the finest particles. Some preliminary results of the calculation are published in an extremely brief form in the paper presented as the appendix. H.Tammet is going to carry out an extended analysis of size-mobility relation for nanometric particles and present the results at the European Aerosol Conference, September 1992. The software of VIE-08 should be examined to find the easiest way to use the results in the calibration of the instrument.

Project EAS
ELECTRICAL AEROSOL SPECTROMETER

Background

Multichannel differential mobility spectrometers have been a subject of R&D in Tartu University during last 20 years. The principles and technical data of EAS are described in the appendix. 5 instruments have been manufactured since the publication of this paper. Some essential improvements have been introduced in last years.

Applications

The favourable specific features of EAS are wide range from 10 nanometers (or less) to 10 micrometers, high sensitivity, quick response and correct measurements in situation of fluctuating aerosol. The first of these features is supported by the usage of two simultaneous particle chargers and last two by the simultaneous multichannel measurement principle.

EAS is well-adapted to carry out the long-period continuous outdoor measurements.

High aerosol flow rate about 48 l/min was chosen for reaching the high sensitivity needed in some applications. On the other hand, the high flow rate is an unfavourable feature in some laboratory experiments where pure gases are used. Another unfavourable feature in laboratory applications is the requirement to avoid overpressure or underpressure of the measured aerosol.

It follows that EAS has some considerable advantages in measurements of environmental aerosols when compared with the well known instruments as TSI models EAA30 and 3932, and HAUKE models VIE-07/08. On the other hand, EAS is not well-adapted for some laboratory experiments. Thus, EAS cannot replace the listed instruments in laboratory and they have complementary fields of applications.

Stage of development

The draft documentation and know-how for manufacturing of EAS do exist, but some additional development is required because the existing instruments have been built using Soviet electronic components. Using the western components and a complete data acquisition unit would improve the technical reliability of the instrument and reduce the extent of labour of manufacturing it.

A Finnish company has expressed its interest in commercializing EAS in cooperation with the authors of the instrument. They have detailed information about the features of the instrument as one EAS was used in a Finnish university for half a year. A small stock company AIREL Ltd is in the stage of establishing itself in Tartu to solve the possible business problems (the authors of EAS A. Mirme, H. Tammet and E. Tamm are among the founding members of the company). However, no agreements or contracts have been concluded yet. The Finnish company is hesitating because the selling of the sophisticated and expensive instrument is a big problem for a newcomer in the market. The personal opinion of H. Tammet is that the real chances of the Finnish company in this business are not commendable.

For the modernization of EAS additional financial resources of 100.000 USD as minimum, labour of the team in Tartu and about 1.5 years time will be needed.

This should result in the documentation, improved software and two instruments, one for demonstration and experiments, another for sale. The AIREL Ltd will stay passive until some western company able to market EAS, will buy the stocks for USD 100.000 or more. Estonian members have no considerable financial resources and they intend to pay their stocks by know-how. The value of the know-how is a subject of negotiations.