EXPERIMENTAL STUDY USING NUCLEAR DETECTORS FOR DETECTION AND MEASUREMENTS OF SOME PROPERTIES OF IONIZING RADIATIONS

By

Etimad Abd El-Gany Gad
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SCIENTIFIC BIOGRAPHY

Name : Eitmad Abd El Gany Gad.

B.Sc.: General Degree in Mathematics and Physics; Grade "Very Good" from University College for Girls Ain Shams University (June 1961).

M.Sc.: Nuclear Physics from University College for Girls Ain Shams University, (December 1966).

Publications:

1 - "A Single-grid Spark Counter with double wire anode" Arab Journal of Nuclear Sciences and Application, 2, 105 (1969).

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ABSTRACT

The design and performance of the wire-plane corona counters in air are investigated and discussed.

The long dead time and cathode corrosion of the spark counter for heavily ionising radiation have been overcome by operating the counter in the streamer mode.

The streamer and spark mode of operation have been examined and the related mechanism is also studied.

In the case of a single-wire counter, investigations were made on the counting characteristics in relation to their dependence on electrode separation, external load resistance, anode wire material and diameter, area of cathode, and humidity.

Also multi-wire anode streamer counters and multi-plane anode streamer counters were constructed and their operating characteristics were studied.

The sensitivity of the wire-plane streamer counter was examined when an alpha source was moved perpendicular to the anode wire and parallel to the plate. The effect of anode wires separation on the detection efficiency of the counter was studied.

The extrapolated number-distance range in air is given for Po^{210} alpha-particles in air.

The space-charge-free field for wire-plane configuration had been treated and the lines of forces as well as the equi-potential surfaces were represented. From the experimental results the detector effective volume was determined for different values of electrode separation and different anode wire diameters.

The fitting of Popkov's formula, to the corona current experimental results showed that reasonable agreement could be obtained only when the empirical constant P (introduced to take into account the nonuniform current distribution) was given a certain value which varied with the parameters as well as with the intensity of corona.

A theoretical analysis of the electric field distribution in the ionisation layer of the corona discharge under equivalent steady state conditions is represented. Using available experimental data on ionisation and attachment coefficients in air, the condition for corona onset is analysed on the basis of the Townsend theory. Subsequently, the field distribution in the corona layer is determined for different values of total equivalent Steady-State Corona current.

C O N T E N T S

CHAPTER III

SINGLE-WIRE COUNTER

CHAPTER IV

MULTI-WIRE STREAMER COUNTERS

CHAPTER V

SENSITIVITY OF STREAMER COUNTERS

CHAPTER VI

RANGE OF ALPHA PARTICLES

CHAPTER VII

SPACE-CHARGE FREE FIELD IN STREAMER COUNTERS

CHAPTER VIII

APPLICATION OF POPKOV FORMULA TO STREAMER WIRE-PLANE CORONA

CHAPTER IX

CORONA DISCHARGE AND BASIC PROCESSES OF GASEOUS ELECTRONICS

INTRODUCTION(1-6)

A Nuclear Counter can be defined as any device which will detect and count individual charged particles arising from radioactive disintegrations. The nuclear counters in most frequent use today are the ionisation chamber, the proportional counter, the Geiger Muller counter and the Scintillation Counter. The instruments for detecting nuclear radiation which were available to early workers in the field of radioactivity were limited by the technology of the period. As new techniques and components have become available, a range of radiation detectors has been developed exploting various basic method of which the theory and technology are on a sufficiently firm basis to allow of a unified presentation.

The fundamental mechanism underlying the operation of all nuclear radiation detectors is the energy dissipated by a charged particle in a suitable medium, and the distribution of this energy among excited states in the detecting material. Thus in place of the single charged particle which provided the energy, these are produced many units of excitation. These may take the form of ionized atoms and free electrons, or of light quanta emitted from excited centers in a phosphor as these return to the ground state. The separated charges in an ionized medium may be collected and the total quantity of electricity measured. Light quanta may be obsorbed in a photo-electric surface, causing the emission of photoelectrons, which can also be collected and the charge magnitude measured.

One or other of these two processes is employed in the types of detector which are most widely used, namely, ionisation chamber, proportional and Geiger Counters, and Scintillation Counters. In all of these instruments, a part of the energy of the charged particle is used up in the ultimate production of a pulse of electric charge. A large portion of the energy dissipated in matter must however appear as heat, and it is therefore possible to detect a sufficiently high energy flux by some form of thermal sensitive device, such as a thermocouple.

The excitation of a medium by the passage of a charged particle may initiate chemical reactions, or in some other way permanently alter the state of the material, as for instance happen in a photographic emulsion. The instruments using these effects are called " +ve detectors ". Since they will go on storing up information until they are examined but do not of themselves produce a signal. A direct detection of the neutrino has so far been unsuccessful, since its interaction with matter is extremely small. Most of the detectors discribed here measure the ionisation caused by the passage of a charged particle through a suitable material.

Nuclear-radiation detection systems can be classified as to whether their operation, is of the pulse type or not. In the pulse type operation, the output of the detector is a series of signals seperated or resolved in time. Each signal represents the interaction of a nuclear particle with the detector. The Geiger-Muller tube and the Spark Counter are example of pulse type detectors. In the nonpulse type of operation of a detection system, the quantity measured directly is the average effect due to many interactions of the radiation with the detector. The detectors to be considered fall into three general categories:

1. Gas-filled devices in which electric charges are transported between a pair of electrodes as a result of ionization produced by radiation; and also the mobility of charge carriers is of the importance, while the detector geometry and value of electric field also affect the performance of the device.

2. Scintillation Counters in which excitation by radiation gives rise to small flashes of light; the decay time of the phosphor largely determines the resolving time of the apparatus, while the very small delays in secondary emission have little effect.

3. Conduction Counters in which the electrical conductivity of insulators or semi-conductors is temporarily increased by the passage of ionization radiation.

However, we shall concern ourselves here with a general survay about the gas-filled counters, as the present thesis will deal with the development of streamer corona counter which is a gas counter operated in the corona region.

Gas-Filled Counter:

Basic Theory of elementary Gas-filled counter:

The problem of devising counters for the detection of radiation, and making them instruments both of sensitivity and precision, so that they will count accurately and yield reproducible results, has been worked upon by investigators since the event of radioactivity. Many varieties of detector, each having its own characteristic features, have been devised, but the most commonly used detectors employ two electrodes in a gas, and make use of the ionization resulting from the passage of radiation through the gas. In its simplest form, such a detection system may consist of a metal cylinder and an axially-mounted wire. As early as 1908 Rutherford and Geiger had used a device. By applying a potential between the cylindrical cathode and the wire anode, they found that the current through the detecting vessel due to the ionization from the entrance of an alpha particle was magnified sufficiently to give a marked deflection on a moderately sensitive electrometer. The process of ionization, which essentially means the removal of an electron from a neutral atom of gas