DOUBLE BETA COINCIDENCE SPECTROMETER

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Tirada aparte de Physica XVIII, no 12, Dic. 1952.

Physica XVIII, no 12 December 1952

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The analysis of the coincidence method using a coincidence beta spectrometer shows us that this instrument must fulfil the following conditions: 1) Independent energy measurement in the counter-spectrometer systems. 2) Big gathering power and good resolving power in the counter-spectrometer systems. 3) Posibility of reducing to a negligeable value with absorbing materials, the counts produced by gamma rays. 4) Optimum location of the counters to make the cosmic-rays coincidence counts negligeable. 5) Counter outside of the magnetic field.

An instrument which fulfils these conditions is that developed by O. Kofoed-Hansen, J. Lindhard and O. B. Nielsen[1]) adapted as a double coincidence spectrometer, as results from the following considerations.

If the magnetic field of this instrument is refered to a cylindrical coordinate system (z, r, φ) its components are $H_z = 0$; $H_r = 0$; $H_\varphi = A/r$; where A is a constant.

It is possible to obtain such a magnetic field with an electromagnet of several pole pieces like that of the Fig. 1.

The set of pole pieces of this electromagnet, form a segmented torus in which z is the cylindrical symmetry axis. The winding of these pole pieces is done as if they were segments of a wounded torus.

The specified magnetic field is obtained only in the inner part of the torus. The cross section of the torus with a plane containing the z-axis may be chosen arbitrarily.

Considering a radioactive point source located in z_s it is necessary that the beta-rays going through the magnetic field are focused in z_f (Figs. 1 and 2).

The principal properties of the electron trajectories in the magnetic field depend upon the constant K, ratio between p/e and A, where p is the momentum and e the charge of the beta-particle.

In a cross section of the torus (Fig. 2) we can see the entrance and exit limiting curves of the magnetic field for the beta-particles: The shape of these curves and the value of K must be selected so as to produce the focalization of the beta-particles.

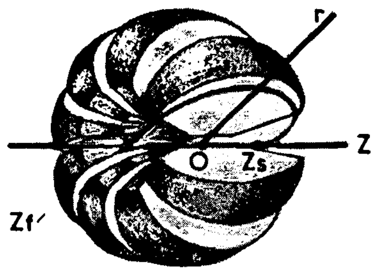

Fig. 1. Electromagnet to obtain the magnetic field $H_z = H_r = 0$; $H_\varphi = A/r$

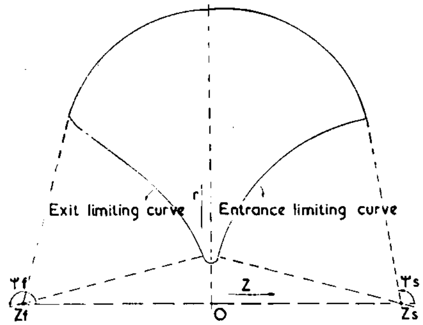

Fig. 2. Cross-section of the torus with a plane containing the z-axis.

There are infinite pairs of limiting curves which fulfil the conditions: *a*) z_f is the focusing point of all the beta-particles emitted in z_s which go through the magnetic field *b*) both points are located symmetrically respect the plane $z = 0$. Of these the pair of curves for which the perturbation due to magnetic stray fields is minimum, is chosen.

If ψ_s is the emission angle of the beta-particles refered to the positive z-axis it is imposed that its value varies between $100° \leqslant \psi_s \leqslant 170°$. If also the condition that the entrance limiting curve is an arc of a circle with center in z_s is imposed, the optimum exit limiting curve as a function of K is represented in the Fig. 2. The resulting optimum value of K is 0.57.

The family of trajectories of the beta-particles is asymmetrical as a result from the above mentioned conditions. The general formulas to resolve the problems of focusing, image formation and dispersion are given *), and with the help of them the resolving power

*) These are not given here because of the limitation of space. The complete work will be published in Buenós Aires.

for all the possible arrangements of this type of instrument may be calculated.

By observing the following tables it is possible to get an idea of the properties of this instrument.

TABLE I

ψ^0_s	b_w	$P.d$
100	0.98	31
110	0.94	28
120	0.86	25
130	0.76	22
140	0.64	21
150	0.50	19

TABLE II

ψ_s	b_w'	$P.d$
100	0.98	82
110	0.94	80
120	0.86	44
130	0.76	25
140	0.64	18
150	0.50	11

In them b_w is a number proportional to the quantity of beta-particles gathered at z_f whose emission angle is ψ_s, with respect to the total number of emited beta particles. $P.d$ is the product of the base resolving power times the diameter d in centimeters of the plane circular radioactive specimen.

Table I gives the properties of one gap when the radioactive disc is placed perpendicular to the bisecting plane of the gap in question and with its center in z_f.

Table II is valid for all the gaps when the radioactive disc is placed perpendicular to the z-axis with its center in z_f.

Such values are calculated assuming:

1) $Oz_s = -Oz_f = 27$ cm.

2) Counter slit equal to the image of the radioactive specimen, for each value of ψ_s.

In the case of Table II and having an instrument with eight gaps each of them of 10° aperture and with $d = 0.6$ cm the resolving power is aproximately 100 and the gathering power of 8% of 4π.

A double coincidence spectrometer composed of two spectrometers like that mentioned which have common z-axis and radioactive source, fulfils the five fundamental conditions.

Received 6-9-52.

REFERENCE

1) Kofoed-Hansen, O., Linhard, J. and Nielsen, O. B., K. Danske. Vidensk. Selsk. mat. fys. Medd. **25** (No 16) 1950.