LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Possibility of Determining the Energy of the Cosmic β-Particles by Magnetic Deflection

In a recent letter to this section, Tuve[1] has pointed out how the scope of the Bothe and Kolhörster[2] coincidence method of investigating high-velocity β-particles can be greatly enlarged by making use of multiple coincidences in three of more electron-counting-tubes instead of the usual method of counting coincidences in only two counters. As Tuve has shown, there are two important advantages in this method: (1) a pair of counters can be used to define a beam of β-particles which is subsequently picked up by a third counter after being scattered, deflected by a magnetic field or otherwise experimented upon, and (2) the number of multiple coincidences occurring by chance can be reduced to a much smaller fraction of the true coincidences, making it possible to work with a beam of much smaller angle than can be used with only two counters.

When Tuve's note appeared, the writer had begun an experiment based on exactly these considerations in an attempt to obtain further information on the nature of the cosmic β-particles discovered by Skobelzyn[3] and investigated by Bothe and Kolhörster.[2] It is planned to attempt a magnetic deflection of these particles, for such an experiment would test the possibility that they may be protons as well asgive a direct measure of their energy. Definite knowledge of their energy distribution would be of assistance in deciding whether these particles are the actual cosmic rays or are of a secondary nature.

It may be of interest to describe an experimental arrangement, (at present under construction), by means of which it appears feasible to measure the energy of β-particles (or protons) having energy up to the value of 10^9 electron-volts which these particles are estimated to have. A pair of Geiger-Müller[4] tube-counters will be used to "collimate" a beam of the particles, which are then passed through a region of strong magnetic field and are finally detected by a third counter placed at a suitable distance. By counting the number of particles which produce a triple coincidence in passing through all three counters, and by arranging the third counter to be suitably movable with respect to the axis of the apparatus, it will be possible to measure the deflection of the beam if sufficient deflection can be obtained. Calculation shows that with counting tubes of sufficient area and subtending a large enough solid angle to keep the intensity high enough to be measurable, a very strong magnetic field is necessary. Furthermore, on account of the necessity of using large counters, (our present "collimating" tubes are 4.4 cm in diameter and 27 cm long), this field must be produced over a considerable volume. These difficulties may be overcome by a device suggested by Skobelzyn,[3] who points out that magnetic deflection of particles of such enormous penetrating power can be produced by passing them directly through a magnetized iron bar. By this method it will be possible to produce a magnetic induction of about 20,000 over a sufficient volume. The loss of energy of the rays in passing through the 15 cm of iron which will be used is not serious since particles of 10^9 *e*-volts energy can be expected to experience a loss of only about 12 percent.

[1] M. A. Tuve, Phys. Rev. **35**, 651, (1930).

[2] W. Bothe and W. Kolhörster, Zeits. f. Physik **56**, 751, (1929).

[3] D. Skobelzyn, Zeits. f. Physik **54**, 686, (1929).

[4] H. Geiger and W. Müller, Phys. Zeits. **29**, 839, (1928).

A widening of the beam due to straggling in the iron is estimated to be negligible for particles of such high energy. Calculation shows that by choice of suitable geometrical conditions and under the assumption of a magnetic induction of 20,000 over a 15 cm path a deflection equal to the width of the beam (about 8 cm) can be obtained for β-particles with the assumed energy of 10^9 e-volts. A somewhat smaller but still detectable deflection can be expected for protons of the same energy. Intensity considerations indicate that under these conditions the number of true triple coincidences will be sufficient to be measurable by a few hours of registration and that the number of such coincidences occurring by chance can be reduced to a small fraction of the true ones.

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April 2, 1930.

Magnetic Moment of the Sulfur Molecule

It is perhaps an open question as to whether the oxygen molecule is singly or doubly bound. According to Heitler and London the $^3\Sigma$ state indicates a singly bound molecule but Heitler and Herzberg have suggested that the second valence may reside in the exchange degeneracy of the electron orbits without involving the spins.

In the case of the sulfur molecule S_2 the evidence is more definite. Sulfur does not often form double bonds, and the fact that sulfur is a solid at ordinary temperatures and even in the vapor state is largely polymerized, indicates that the S_2 molecule is highly unsaturated. A $^3\Sigma$ state is to be expected.

The magnetic moment of the S^2 molecule has been determined in this laboratory and the prediction is confirmed. Since most of the S_2 molecules are in states of high rotational energy it would not be expected that the field would break the coupling between the spins and the rotational axis. Under these circumstances only a widening of the molecular beam in the inhomogeneous field would occur and this result has been obtained in the experiments. In some cases however a faint satellite line on the side of the broadened central image has been observed. This line is on the side next the knife edge where the field is strongest. It seems probable that the field is strong enough here to uncouple the spins from the rotational axis in those molecules in the lower rotational states. If this is the case then the line is one of the three to be expected from a $^3\Sigma$ molecule with strong field quantization.

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Raman Spectra from Sulfur Dioxide

In view of the increasing interest which is being shown in the spectra of polyatomic molecules, we desire to report the results of some Raman effect measurements on sulfur dioxide. The material used was taken from a commercial tank; it was passed over phosphorus pentoxide to dry it and then condensed in a heavy walled Pyrex glass tube 2 cm in diameter and 20 cm long. During the condensation care was taken to exclude moisture; but no further purification than drying was considered necessary since the commercial product is ordinarily much better than 99 percent pure. When this glass tube was nearly filled with liquid, it was sealed off and subsequently used for the light-scattering experiments.

The Raman spectra were obtained with a mercury arc and the plates calibrated with

Table I. *Scattered lines from liquid* SO_2.

Frequency of modified line	Intensity	Frequency of exciting line	Frequency shift
24182.5	v.f.(diffuse)	24705.5	523.0
23560.4	st.	24705.5	1145.1
23371.2*	med.	24516.1	1144.9
23366.1*	weak (diff.)	24705.5	1339.4
22412.5	weak (diff.)	22938.1	525.6
21893.7	v.f.	23039.1	1145.4
21847.8	f.	22995.3	1147.5
21791.4	v.st.	22938.1	1146.7
21597.4	med. (diff.)	22938.1	1340.7

* These two lines overlapped on the plates; separate measurement was attempted since one line was much sharper than the other.