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 $\beta$-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.

an iron arc. The apparatus and method of measurements were substantially the same as previously used in the case of liquid ammonia (Dickinson, Dillon and Rasetti, Phys. Rev. **34**, 582 (1929)). The results of the measurements are given in Table I. The frequencies of modified lines in $cm^{-1}$, given in the first column, are averages obtained from several plates. Reduction of the calibrating wave-lengths to vacuo has been made.

These modified lines show the existence of three shifts with the following average values; 524.3 $cm^{-1}$, weak (diffuse); 1145.9 $cm^{-1}$, strong; 1340.1 $cm^{-1}$, medium (diffuse). The last two of these shifts agree, within the limits of error, with the frequencies of the two strongest absorptions by gaseous sulfur dioxide found by Coblentz (Carnegie Institute Publication, No. 35, p. 177) in the infrared. The smallest shift lies outside of the range of Coblentz's measurements. It is of interest to recall that such direct agreement between Raman shift and infrared absorption frequency has not been found in the cases of carbon dioxide and carbon disulfide whose molecules have points of similarity with those of sulfur dioxide.

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## On the Reason for Pauli's Exclusion Principle

It is generally recognized nowadays that physics deals primarily with one aspect of human experience; thus has the philosophical contention of Berkeley and Kant become after a century one of the presuppositions of our science. It was substantially this principle that led Heisenberg, first to his quantum mechanics, and then to the Indetermination Principle.

An interesting attempt has been made by Condon and Mack (Phys. Rev. **35**, 579, 1930) to find in the same principle the ground for Pauli's exclusion rule. It is suggested that human beings are themselves in an antisymmetric quantum state and that for this reason we can perceive only those material structures which are likewise in an antisymmetric state; hence, for us, the apparent validity of the exclusion rule. By implication there may exist all round us another set of physical systems in non-antisymmetric states without our being able to perceive them at all; presumably (if I understand correctly) there may also exist another race of humans who are experimenting upon those other systems but who, not being quantum-mechanically antisymmetric, can no more perceive us than we can perceive them.

An adequate proof seems to be lacking, however, that such possibilities are actually contained in quantum mechanics; certainly they are not among the familiar results of the theory. If, for example, an "antisymmetric" atom were to encounter a "symmetric" one under a law of interaction that is symmetrical in the electrons of each, then it follows from "resonance" theory that the first atom could never bump the second one into an antisymmetric state, nor could the second bump the first into a symmetric state; each atom would retain its initial character. There is, however, no indication that each would simply pass by as if the other were not there at all. The photons emitted by symmetric atoms would also, on current theory, be indistinguishable from photons of the same size emitted by other atoms and so should be observable. Since the same considerations hold for systems of any size, no reason is apparent why an antisymmetric physicist should be unable to perceive at all a symmetric world, or, perceiving it, to form an antisymmetric (?) concept of its symmetry.

The same consideration seems applicable at first sight to Condon and Mack's alternative suggestion that the non-antisymmetric electrons may all have vanished from our ken into Dirac states of negative energy, which for such electrons form a set having no "bottom." It remains to be shown that the endless dropping of these electrons into ever greater depths of the abyss would have no effect upon our instruments. Perhaps they are physically imperceptible just as an electron or photon with infinite positive energy has a zero coefficient of absorption and so is physically non-existent. I hope the authors of the paper will give us an exact mathematical analysis of this point.

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