for the determination of the absolute motion of the earth. These observations involved the making of about 200,000 single readings of the position of the interference fringes, and lead to more than 25,000 single values of both the right ascension and declination of the apex of the motion.

The ether-drift effect in the interferometer, as is well known, is a second order effect, and the observations correctly define the line in which the absolute motion takes place, but they do not determine whether the motion in this line is positive or negative.

At the Kansas City meeting in December, 1925, before the completion of the Mount Wilson observations, a report was made showing that the experiment gives evidence of a cosmic motion of the solar system, but which failed to identify the effects of the orbital motion, though it seemed that the observations should have been quite sufficient for this purpose.[2]

In the autumn of 1932, a reanalysis of the problem was made, based upon the alternative possibility that the motion of the solar system is in the cosmic line previously determined, but is in the opposite direction, being directed southward. This gives wholly consistent results, leading for the first time to a definite quantitative determination of the absolute motion of the solar system, and to a positive detection of the effect of the motion of the earth in its orbit.

The apex of the cosmic motion of the solar system is located in the right ascension of 4 h., 56 m., and in declination 70° 30′ south, diametrically opposite the apex previously announced. The velocity of the cosmic motion is determined by comparison with the known velocity, 30 kilometers per second, of the earth's orbital motion, and has the value of 208 kilometers per second. For some unexplained reason the observed displacement of the interference fringes in the interferometer corresponds to about one twentieth of the full velocity. This might be accounted for by an incomplete Lorentz contraction, or by Stokes's theory of a dragged ether.

The location of this apex is in the southern constellation Dorado, the Sword-Fish, and is about 20° south of the star, Canopus, the second brightest star in the heavens. It is in the midst of the famous Great Magellanic Cloud of stars. The apex is only about 6° from the pole of the ecliptic; thus the indicated motion of the solar system is almost perpendicular to the plane of the ecliptic. This suggests that the solar system might be thought of as a dynamic disk which is being pulled through a resisting medium, and which therefore sets itself perpendicular to the line of motion.

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[2] SCIENCE, 63: 433–443, 1926.

THE PHOSPHORESCENCE OF SOLID NITROGEN AND ITS RELATION TO CRYSTAL STRUCTURE[1]

IN 1924 it was shown that solidified nitrogen, when exposed to electric rays, emitted an intense luminescence, consisting of bands, a number of which remained in the afterglow. Thus we have the case of a chemical element having the properties of a phosphorescent body.

When the temperature is raised above 35.5° K, solid nitrogen passes over from the phosphorescent α-form to another modification β, which has lost its phosphorescent power.

This phenomenon gives an important point of attack for the elucidation of the phosphorescent process. For this purpose the luminescent phenomena were analyzed and interpreted, and secondly the crystal structures of the two modifications of solid nitrogen were analyzed by means of Röntgen rays.

The analysis of the luminescent band-spectra led to the view that the bands appearing in the afterglow are due to "forbidden" electronic transitions from metastable molecular states. Thus the ε-system emitted from solid nitrogen corresponds to an electronic transition from the metastable A-state to the normal state of the nitrogen molecules.

The Röntgen-ray analysis gave for α-nitrogen a cubical structure, where the atoms of the molecular elements are arranged according to the space group T^4 and where the molecular axes have fixed positions in the space lattice. This structure lets us understand that the metastable states (which in the gaseous form are soon destroyed) in the α-form may be left undisturbed for a time sufficiently long for the forbidden transition to take place.

The analysis of the β-form was even more difficult, but finally it was found by us and independently by Ruheman that β-nitrogen has a hexagonal structure and that the elementary cell has dimensions nearly corresponding to a hexagonal closest packing of spheres.

For our problem it was of importance to go a step further and try to find out the positions of the individual atoms; but it appeared that the Röntgen reflections could only be accounted for by assuming the centers of the two atoms of a molecular element fall in the center of the molecules. This means that the individual atoms have no fixed positions and that the molecules rotate in the lattice. The rotating molecules require more space, which is seen from the fact that

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[1] Read before the National Academy of Sciences, Washington, D. C., April, 1933.

the molecular volume by the transformation increases from 45.37 Å^3 to 47.12 Å^3. The rotating molecules also explain the rapid fall of the Röntgen-ray reflections with increasing deflection-angle. That molecular rotation can occur in the solid state is evident from the two modifications of hydrogen, and the problem has been theoretically treated by Paceling. In this connection, it is of interest to mention that the oxygen modification, stable above -229.5, was recently found by us to have a cubical lattice with rotating molecules. On the basis of our interpretation of the luminescence, we immediately see the reason why the β-modification has lost its phosphorescent power.

The rotational motions of the molecular elements of the lattice will disturb the metastable states just as in the gaseous system before the forbidden transitions can take place.

Reasons are given for the view that the excitation consists in a kind of dissociation process and that recombination takes place through certain metastable states. The phosphorescence, at any rate in our case, should be closely related to chemiluminescence, the main difference being that in the case of phosphorescence the reacting chemical substances are first to be formed through the excitation process.

L. VEGARD

COUPLED REACTIONS IN BIOLOGICAL SYSTEMS

THE following is a summary of some preliminary investigations of two coupled reactions in biological systems: (1) The reduction of pyruvate to lactate by means of the energy of the anaerobic oxidation of formate to bicarbonate, and (2) the reduction of fumarate to succinate through the anaerobic oxidation of lactate to pyruvate. Toluene treated *B. coli* served as enzyme system for both reactions.

It was found in both instances that an intermediate substance was necessary which could be reduced at the locus where the one metabolite was oxidized, and reoxidized where the other was reduced. The intermediate substances were methylene violet for the lactate-pyruvate-formate-bicarbonate system, and methylene blue for the succinate-fumarate-lactate-pyruvate system. Without these mediators no reaction occurred.

These findings support the hypothesis of active centers proposed by Quastel.[1] They indicate that "half reactions" can not occur, and therefore the necessity for mediators, or carriers of energy from the point where energy is liberated to the point where it is used, when the energy-liberating and energy-absorbing mechanisms are separate; *i.e.*, that in the toluene treated *B. coli* there is no mechanism corresponding to metallic conduction. They show also that toluene treated *B. coli* contain no mediators capable of serving in the two systems studied.

Further, these experiments suggest that when oxygen is used *in vivo* the centers at which oxygen is bound must be intimately associated with the dehydrogenase mechanisms, or that one or more mediators similar in their function to reversible dyes intervene between the oxygen binding and the dehydrogenase mechanisms. These alternatives are not mutually exclusive. They may co-exist and even supplement each other, as possibly, for example, in the case of the non-iron-containing respiratory ferment system described by Warburg and Christian.[2]

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[1] J. H. Quastel, *Biochem. Jour.*, 20: 166, 1926.

[2] O. Warburg and W. Christian, *Biochem. Zeits.*, 258: 496, 1933.

SOME ASPECTS OF INTERMEDIARY PROTEIN METABOLISM

THE exogenous origin of creatine was first demonstrated by Levene and Kristeller in 1909 in their protein feeding experiments with cases of muscular dystrophy. In 1929, we reported[1] that glycine fed to patients with muscular dystrophy produced a marked rise in creatine excretion (confirmed by Thomas *et al.*,[2] and others), whereas glutamic acid and cystine had no effect. Studies with a number of other amino acids and various other substances were also reported. The effect of the removal of glycine and of glutamic acid from the metabolic mixture through the feeding of benzoic acid and phenylacetic acid, respectively, was investigated. It was found that the former produced a marked drop in creatine, while the latter was without effect. We are inclined to infer from our experiments that the feeding of brombenzene, which removes cysteine from the metabolic mixture, would be without effect on creatine excretion. Owing to the possible toxicity of the substance we intend to carry out suitable animal experiments instead. The chart shows only the essential results of a few representative experiments.[3]

Hippuric acid, phenylacetyl glutamine and bromphenyl mercapturic acid formation: The finding that the feeding of benzoic acid and phenyl acetic acid in proper amounts may have no effect upon the total nitrogen catabolism, although there are appreciable amounts of glycine and glutamic acid, respectively, lost to the body as a result of "Abfang" processes,

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[1] *Am. Jour. Physiol.* 90, 296.

[2] *Z. physiol. Chem.* 214, 121.

[3] The significance of our detailed nitrogen and sulfur studies can not be discussed here, due to lack of space.