Letters to the Editor.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

On the Oxygen Spectral Line $\lambda = 5577.35$ Å.

A number of investigators, including Merton, Barratt, Johnson, Cameron and others, have shown that the spectrum of an element in the gaseous state can be profoundly modified if an electric discharge is passed through it when one or other of the rare gases helium, neon, argon is mixed in excess with it.

For example, Merton and Filley showed that by this method it is possible to enhance greatly the arc spectrum of atomic nitrogen and even to isolate it completely from the spark spectrum of this element.

Again, it was shown a year ago by McLennan and Shrum that a line of weak intensity existed at $\lambda 5577.35$ Å in the spectrum of oxygen, and that this line could be considerably strengthened when helium or neon were added in excess to oxygen excited by the passage of an electric discharge through it.

As McLennan and Shrum put forward the view that this line in the spectrum of oxygen is identical with the famous "green line" $\lambda 5577$ Å, observed in the spectrum of the light from the night sky, and in the spectrum of the aurora, we were led to engage during this year in a rather exhaustive study of the main characteristics of the line. The results of this investigation will be given in detail elsewhere, but in the meantime we think it well to state here a few results that are of special interest now.

(1) The spectral line $\lambda 5577$ Å has been shown to be obtainable with pure oxygen and with intensity the strongest when the gas is at a pressure of two millimetres of mercury and the exciting electrical discharge is passed through a tube about one metre long and three centimetres in diameter.

(2) When currents varying in strength up to 160 milliamperes were used, the intensity of the line steadily increased with the strength of the exciting electrical current.

(3) A new series of measurements has shown that the wavelength of this spectral line is very close to $\lambda 5577.35$ Å.

(4) This spectral line, $\lambda 5577.35$ Å, has never been observed in our experiments in the spectrum of any electrical discharge in the absence of oxygen.

(5) When an electrical discharge was passed through oxygen at a pressure of 2 mm. of mercury with a high pressure of this or other gases, the line was obtained with strongest intensity when the partial pressure of the helium was about 20 mm. of mercury.

(6) A series of carefully executed experiments has shown that the power possessed by the rare gases of enhancing the oxygen line $\lambda 5577.35$ Å, assuming the strength of the line in oxygen alone to be 1, is as follows: helium 1.7, neon 4.5, argon 84.2.

(7) When argon in excess was mixed with oxygen the line $\lambda 5577.35$ Å was obtained with an intensity greater than that of any known line in the spectrum of atomic oxygen having a wavelength shorter than $\lambda 6000$ Å.

(8) Observations with a powerful echelon spectroscope showed that the oxygen line $\lambda 5577.35$ Å is simple and without any fine structure.

(9) In studying the Zeeman effect with the line $\lambda 5577.35$ Å it was found that magnetic fields of weak to moderate intensity produced a symmetrical broadening of the line, the magnitude and the character of this broadening being of the order and of the nature respectively of that usually shown by spectral lines having an atomic origin.

(10) It would appear that this spectral line $\lambda 5577.35$ Å originates in an electron transition between atomic levels for oxygen provided by one or other of two new singlet-triplet schemes that were based on Hund's theory and were recently put forward (Proc. Roy. Soc., July 1926) by McLennan, Grayson Smith and McClay.

J. C. McLennan.

H. J. McLeod (Student of National Research Council of Canada).

The Physical Laboratory,
University of Toronto,
September 1.

Interference and Corpuscular Light.

In the new wave theory of matter (Einstein, L. de Broglie, Schrödinger), the material point is conceived as a singularity in a wave. More precisely, in the absence of any field of force, the wave phenomenon called 'material point' is represented by a sinusoidal solution of the equation:

$$\Delta u - \frac{\partial^2 u}{\partial \xi^2} = \frac{4\pi}{h} m \frac{\partial^2 u}{\partial \eta^2}, \quad \ldots \quad (1)$$

where $m$ is a constant characteristic of the wave (proper mass of the material point). The function $u$ has a uniformly moving singularity which is the material point. If the point at rest has a spherical symmetry, then the solution of (1) will be (the line of motion being chosen as $\xi$ axis)

$$u = \frac{A}{\sqrt{\pi^2 + (\xi - \eta)^2}} \sin \nu \pi \frac{I - \nu^2}{\xi^2}, \quad \ldots \quad (2)$$

Further, the energy of the moving point is identical with the product $hv$.

In the special case of the light quanta, we must suppose $m_0$ to be equal to an extremely small quantity if not to zero. Then the wave equation (1) reduces to the classical form:

$$\Delta m = \frac{\partial^2 m}{\partial \xi^2}, \quad \ldots \quad (1')$$

For each problem of interference or diffraction, classical optics tries to find a solution of the form:

$$u = a(x, y, z) \sin (\omega t - q(x, y, z)), \quad \ldots \quad (2)$$

satisfying the adapted limiting conditions. But, for the new mechanics, the motion of the light quanta is given by a solution of (1') of the form:

$$u = f(x, y, z) e^{i(\omega t - q(x, y, z))}, \quad \ldots \quad (3)$$

where the amplitude $f$ has many moving singularities. The function $f$ is to be the same in (2) and (3), and the singularities, i.e., the light quanta, must describe the curves normal to the surfaces $\phi = \text{Constant}$. In substituting (2) and (3) in (1'), we get the two following relations connecting the classical amplitude $a$ and the 'granulated' amplitude $f$, respectively, with the phase-function $\phi$:

$$\frac{2 \partial a}{\partial \phi} \frac{\partial a}{\partial n} - \frac{1}{2} \frac{\partial a}{\partial n} = - \frac{\partial f}{\partial \phi} \frac{\partial f}{\partial n}, \quad \ldots \quad (4)$$

$$\frac{\partial f}{\partial n} + \frac{\partial f}{\partial \phi} = - \frac{1}{2} \frac{\partial f}{\partial \phi} \frac{\partial f}{\partial n}, \quad \ldots \quad (5)$$

$dn$ being an element of trajectory.

1 Of course it remains to prove the existence of such a solution of equation (1) in each case.
Now, by analogy with the solution for the free spherical material point, we can suppose that the quantity \( j(\delta f/\delta n) \) is zero at the points occupied by the light quants at a given instant. Then the velocity of a quant in passing by a point \( M \) will be, for example, 5:

\[
\mathbf{v}_M = \left( -\frac{\delta f_1}{\delta n}, \frac{\delta f_2}{\delta n} \right) = \mathbf{e} \frac{\delta \phi}{\delta n}. \quad . \end{align}
\]

The motion of the quants is permanent and \(-\mathbf{e} \phi\) plays the part of a velocity potential. But during the motion, the number of quants remains constant and along a very thin tube of trajectories, we must have:

\[
p \mathbf{v} = \text{constant}, \quad . \end{align}
\]

where \( p \) is the mean density of light quants in the wave and \( \sigma \) the section of the tube.

Hence, we conclude that:

\[
\frac{1}{\rho} \frac{\partial \rho}{\partial t} + \frac{1}{\omega} \frac{\partial \omega}{\partial t} = 0. \quad . \end{align}
\]

But infinitesimal geometry teaches us that the last term of the first member is equal to twice the mean curvature of the phase surface. Thus, equation (8) gives easily:

\[
\frac{1}{\rho} \frac{\partial \rho}{\partial t} = -\mathbf{a} \cdot \mathbf{e} \frac{\partial \phi}{\partial n}. \quad . \end{align}
\]

and by comparing (9) and (4) we see that:

\[
p = c \cdot a^2. \quad . \end{align}
\]

The density of light quants is to be taken proportional to the classical intensity. In the dark fringes of the classical theory, the density of quants will be zero, but in a bright fringe a great number of quants will pass. Now, the motion being permanent, this explanation of the experimental facts will still be available if the light is very weak (Taylor's experiment); we have only to define the density of quants by a time average instead of a space average.

LOUIS DE BROGLIE.

Paris, August 27.

Science and Psychical Research.

I have read the editorial note appended to the letters on this subject published in NATURE of September 11, and desiring to keep within the limits that you wish to be observed in this discussion, I have tried strictly to confine myself in the following remarks to replying to allegations against myself made by Sir Arthur Conan Doyle in that issue, as also to the specific points raised by Dr. Tillyard in his rejoinder to my letter on this subject published in NATURE of August 28.

Sir Arthur Conan Doyle states that my account of the incidents connected with the Combermere photograph, published in the issue of August 28 "is both inaccurate and misleading." It will, I think, be sufficient to direct attention to one only of Sir Arthur Conan Doyle's statements, to show whether he is, or I am, the more accurate person. After telling how I challenged him to publish, in the Morning Post, the ghost photograph alongside a photograph of the peer taken in life, Sir Arthur Conan Doyle goes on to say (italics are mine) -- "I at once sent up my photograph without any suggestion whatever that it would not reproduce. That statement is pure invention on the part of Mr. Campbell Swinton."

In reply to this, may I quote the opening sentence of Sir Arthur Conan Doyle's letter to the Editor of the Morning Post, published in that paper on April 23? It is as follows:

"I beg to enclose the Combermere photograph. I am advised that it will not reproduce, but you will be the best judge of that."

These two entirely contradictory statements, both from the pen of Sir Arthur Conan Doyle, show how little reliance can be placed upon the accuracy of what he states, and I therefore do not propose to undertake further reference to the remarks contained in his letter to NATURE except to say that they consist of a tissue of misrepresentation, together with a number of statements which are no more accurate than the one quoted above.

With regard to Dr. Tillyard's rejoinder, I should like first of all, to say how much I appreciate the spirit in which he has accepted what may have seemed to him my somewhat provocative criticisms. I must, however, further criticise what he now says.

Dr. Tillyard complains that I do not distinguish between spiritualism and psychical research; but, so far as I can see, the only distinction between the two is that the second includes the first, while I may add that, though the heading under which it appeared was "Science and Psychical Research," Dr. Tillyard's article purported to be a review of a "History of Spiritualism."

Nowhere have I ever suggested that the medium is one of the experimenters, as Dr. Tillyard surmises. On the other hand, I cannot agree with him that the medium is a mere instrument, such as a microscope or spectroscope, for, quite apart from the question of free will, which is probably an illusion, due to the same portion of the brain being concerned in determining both our wishes and our actions, human beings have consciousness and motives, which are things possessed by no man-made instrument or mechanism.

Dr. Tillyard states, "If a medium is found to be fraudulent, then the genuine psychical researcher will not proceed with him, but will endeavour to find a more trustworthy one." But this, anyway, was not the method adopted by Crookes, who, I suppose Dr. Tillyard will agree, was one of the greatest of psychical researchers. If we are to believe the authorised life of Sir William Crookes, written by Dr. Fournier d'Albe, "Crookes does not seem to have taken up the medium (Miss Cook) seriously until after she had been exposed by a Mr. Volckman, who seized 'Katie King' (supposed to be a spirit) and found himself holding the medium (Miss Cook) dressed up."

Furthermore, Miss Cook, who had by then married and become Mrs. Corner, was again exposed by seizure, masquerading as a spirit, by Sir George Sitwell, the well-known baronet. A detailed account of this exposure will be found under the heading "Capture of a Spirit" in the Times of Jan. 12, 1880, while in the Times for Jan. 15 following, there is a letter from the secretary of the British Association of Spiritualists (on whose premises the seance was held), on behalf of the Council of that body, stating that Sir George Sitwell's account of what occurred was substantially correct. Sir George Sitwell quite recently told me that this complete exposure, which had wide publicity, made so great a sensation that it nearly wrecked the whole spiritualistic movement of that time; so Crookes must have known all about it. Yet, a few years later, as recorded in Sir Arthur Conan Doyle's history, we find Crookes giving an unqualified testimonial as to the bona fide mediumship of this twice-convicted impostor.

All scientific men hold Crookes in the highest veneration both as a physicist and as a chemist, but what can they think of his judgment in respect to spiritualistic matters, having regard to what is disclosed above?

Dr. Tillyard mentions the names of Crookes and of four other scientific men who studied spiritualistic