

RESEARCH ARTICLE

# A Resolution of the Wave-Particle Paradox

Donald C. Aucamp, ScD

*Professor Emeritus, Southern Illinois University at Edwardsville, USA.*

Received: 16 February 2026 Accepted: 02 March 2026 Published: 03 March 2026

Corresponding Authors: Donald C. Aucamp, ScD, Professor Emeritus, Southern Illinois University at Edwardsville, USA.

## Abstract

In this work a theory is put forth which explains the results of diffraction grating experiments on photons and electrons and thereby provides a feasible resolution the wave-particle paradox.

## 1. Introduction

It is shown in Aucamp[1-5] that photons are particles which are composed of single electric field corpuscles in the shape of thin, spinning rings or washers which move at the local velocity of light along a line orthogonal to the washer face. These photons therefore have no wavelength or frequency. From these works formulas are derived for Planck's constant, the photoelectric effect, and the structure of the periodic table, so that the theory is held to be inarguable. Moreover, in [6] there is further theoretical confirmation that photons are not waves, in that it is shown the standard wavelength analysis used in diffraction grating experiments is in error. However, in spite of these results, the counter assumption that photons are waves might seemingly appear to have merit in that these experiments correctly identify emission sources, at least when there are many photon arrivals. A second problem, again when there are many arrivals, is that linear patterns emerge on the screens, a result which seemingly is evidence that the emitted photons are waves. Strangely, however, when the arrival rate is low in these experiments, points appear on the screen, a result which indicates that photons are particles. This dual nature of experimental outcomes is known as the wave-particle paradox, which is a problem that has been unresolved for a very long time. In spite of these confusing results, the general assumption today concerning photons is that they are waves with a strange quirk. Possibly a major reason for this is because of the great success of the

wave hypothesis in the identification of photon sources in spectroscopy experiments. For a solution to this problem, it is theorized in this work why these results are to be expected in diffraction grating experiments with the particle theory of [1-5]. In addition, it will be shown why photon experiments correctly identify the sources, even though from [6] the experimental wavelength formula is otherwise in error. While the focus of this work is almost exclusively concerned with photons, at its conclusion diffraction grating experiments with electrons are also briefly analyzed, where it is seen that similar wave-particle results are to be expected.

## 2. Photon Background Theory

The background theory for photons employed in this work is due to Bohr[7] and this author. In Aucamp[1-5] an atomic model is proposed which consists of especially paired orbiting electron strings which, taken as a whole for the entire atom, do not radiate because the total emitted field is constant in space. As this paired condition requires that the atomic number,  $Z$ , be even, it is theorized that any element with an odd value of  $Z$  is not stable by itself.

In the following summary analysis it will be assumed that a single electron in a given atomic orbit with radius  $r=A$  is knocked out of orbit, and that an electron from an outer orbit with radius  $r=B$  moves to replace it. The theory given below by (2.1)-(2.3) is due to Bohr, where  $V$ ,  $K$ ,  $U$ , and  $E$  are the single electron orbital velocity, kinetic energy, potential energy, and

**Citation:** Donald C. Aucamp, ScD. A Resolution of the Wave-Particle Paradox. Open Access Journal of Physics. 2026; 8(2): 41-45.

©The Author(s) 2026. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

radiation, respectively, and where the permittivity of free space is given by  $k_0 = e^2/(4\pi\epsilon_0) \approx 89.8755$ .

$$V = [k_0 / (mr)]^{1/2} \tag{2.1}$$

$$K = m V^2 / 2 = k_0 / (2r) \tag{2.2}$$

$$U = \int_{\infty}^r f dr = \int_{\infty}^r (k_0 / r^2) dr = - k_0 / r \tag{2.3}$$

In addition to this theory a law of radii is derived in [1-5] as follows.

$$r = n^2 r_0 \tag{2.4}$$

In (2.4) law  $n$  is a positive integer, and the first Bohr radius,  $r_0$ , is given by  $r_0 \approx .0529$  nm. Thus,  $A = n_A^2 r_0$  and  $B = n_B^2 r_0$ . In the photon emission process the radiated energy,  $E$ , in an electron move from  $r=B$  to  $r=A$  is given from Bohr as follows

$$E = - (\Delta K + \Delta U) = (k_0/2) (1/A - 1/B) \tag{2.5}$$

Since  $A < B$ , it is seen that  $E > 0$ . Also, from (2.1).

$$V_B / V_A = (A / B)^{1/2} \tag{2.6}$$

Since  $B > A$  it is clear from (2.6) that  $V_A > V_B$ , which might seem strange because the emission radiates energy. The reason for this is due to the potential energy gained,  $\Delta U$ , in the move. Since  $E > 0$  in (2.5), energy is radiated outward. The reader is directed toward [1-5] for more detail.

In addition to the above equations, a photo-electric law which replaces Einstein's [8] theory is derived in [1-5] as follows.

$$ET = h (n_B - n_A) \tag{2.7}$$

Since frequency  $f$  was assumed by Einstein to be given by  $f = 1/T$ , then (2.7) is equivalent in his notation to  $E = hf (n_B - n_A)$ . It is therefore noted that this equation differs from Einstein's photoelectric formula, which is  $E = hf$ . It is argued that the Einstein result is not totally valid when  $n_B - n_A > 1$  because in this case more energy is radiated and the process takes more time, so  $E > hf$ . While it may generally happen that  $n_B - n_A = 1$ , it is argued this is not always the case. Also, concerning (2.7), a valid formula for  $h$  is derived in [1-5] as follows.

$$h = 2 \pi (mr_0 k_0)^{1/2} \tag{2.8}$$

Moreover, if  $\xi$  is the thickness of the washer, the emission time  $T$  can be ascertained by assuming the photon moves at the local velocity of light. If this velocity is  $c$ , then:

$$T = \xi / c \tag{2.9}$$

It is interesting that the formula for  $h$  as given by (2.8) was determined by Bohr in another form in his

correspondence principle theory, in which he combined his planetary model with quantum mechanics in the special case when  $A = n^2 r_0$ ,  $B = (n+1)^2 r_0$ , and  $n \rightarrow \infty$ . However, Bohr in his analysis crucially postulated the validity of the photoelectric effect, which was not done in deriving (2.8). In addition, he also placed severe requirements on  $A$  and  $B$ .

Very important, the theory in [1-5] contradicts Einstein's conclusion that his formula covers all radiation. It clearly does not apply, for example, to radiation which is not caused by electron ejections, such as is the case with radio waves.

### 3. Diffraction Gratings

#### 3.1 Introduction

In 1801 Thomas Young experimentally demonstrated in his double slit experiment that light is apparently a wave. In a modern day version of his work a diffraction grating with many slits is often used. Though there are several kinds, attention is directed to those that transmit photons through identical, parallel slits which are evenly spaced by a distance of  $D$ . In these experiments photons emanate from a source which may use a device of some kind to insure greater purity. The emissions then hit a grating and eventually emerge through the slits in an altered form which will be discussed later. Subsequently, they get extinguished by hitting a screen which is placed moderately far away, at least as compared to  $D$ . The problem studied in this work is to offer an explanation as to why the results created on the screen are individual points when only a small number of photons are involved but linear pattern lines when there are many of them. In addition, it will be shown why the sources can be identified by the standard calculation of the nonexistent wavelength.

Concerning photons, as the results which are points are easily explained if it is assumed that they are shaped as miniscule particles, the remaining problem is then to explain the appearance of the linear pattern lines when there are many arrivals. While these lines can presumably be explained by assuming that the photons are waves, it is reiterated that in [6] there is an error in the theory. Thus, it is argued the only conclusion that appears to have a possibility of being valid is that photons are the particle corpuscles given in [1-5]. In this regard, Nobel physicist Richard Feynman [9] once said that nobody understands quantum mechanics, and that the result of the double-slit experiment is the fundamental mystery of this subject.

Since in [1-5] electrons exist in the atom as paired strings, it is noted from these works that a pair is generally ejected, say from  $r=B$ , to replace a pair from, say,  $r=A$ , rather than just a single electron replacing a single electron. As it turns out that this is an important feature of the radiation process because it is shown that each of the electrons in the pair eventually emits half of a photon in each direction normal to the washer face. Thus, the total emission in each direction consists of two photon halves, which amounts to a complete photon each way. As this feature leads to valid formulas for Planck's constant and the photoelectric effect, it is deemed to be an additional proof of the validity of [1-5]. Based on this theory, it will be simpler and equally accurate in the following analysis to assume that just one electron is ejected at  $r=A$ , and just one electron moves from  $r=B$  to replace it, with the result that just one complete photon is emitted which moves off in just one direction orthogonal to the washer face.

### 3.2 Properties of the Photons Arriving at the Grating

Based on the above analysis, assume a photon in the shape of a ring or washer moves from the source to the grating, which is the result of an electron pair ejection in the source at  $r=A=r_0 n_A^2$  and an electron pair replacement from  $r=B=r_0 n_B^2$ , where  $B>A$ . As explained above, it will be convenient and equally accurate to simply look at just a single photon moving toward the grating. Defining  $E$  as the photon energy,  $T$  as the emission time, and  $\xi$  as the photon washer thickness, and assuming the local velocity of light is  $c$ , then from the previous analysis.

$$\xi = cT \tag{3.2.1}$$

$$ET = h(n_B - n_A) \tag{3.2.2}$$

$$E = (k_0/2) (1/A - 1/B) \tag{3.2.3}$$

By way of note, it is shown in [1-5] that  $\xi/A$  is very small, so that the photon washer is extremely thin. The above three equations imply the following.

$$\xi = ch(n_B - n_A)/E = [ch(n_B - n_A)] / [(k_0/2) (1/A - 1/B)] \tag{3.2.4}$$

Since  $A=n_A r_0^2$  and  $B=n_B r_0^2$ , the values of  $E$  and  $\xi$  depend only on  $A$  and  $B$ . However, it is known that diffraction grating outcomes differ with different elements that are on the same row of the periodic table, where the values of  $A$  and  $B$  are the same. It will be shown in an upcoming work that the experimental differences for elements in the same row of the periodic table are

due to the differing inner electric field content of the emitted photons when they hit the grating.

### 3.3 Action in Contact with the Grating

It is shown in [1-5] that the photon washer shapes have a circumferential length given by  $L=2\pi A$ , which is a fixed value for all the elements in the periodic table row having that particular value of  $A$ . When each photon hits the grating, it is assumed it smashes into it almost flatly, and as a result the arrival ring is squashed into an essentially much larger ring of circumferential length  $L^*$ , which is independent of  $D$ . Since all the elements on the  $n^{\text{th}}$  row of the periodic table have the same value of  $A$ , the value of  $L$  is the same for all of them. Thus, it might be presumed that the resulting value of  $L^*$  would also be the same for all of them. However, it will be shown in this author's upcoming paper that this is not the case, and that  $L^*$  is different for different elements on the same periodic table row. Also, while  $L^*$  may not be strictly constant in a given experiment involving many emanations from a fixed source, it is assumed in this work that it varies very little, percentage-wise, so that the following postulate is assumed to hold.

*Postulate*

$$L^* \approx \varphi(Z) \tag{3.3.1}$$

In (3.3.1)  $\varphi(Z)$  is an assumed fixed function of  $Z$ , which is the atomic number of the source. This approximation is postulated to exist in this work and will be derived in this author's next paper. Thus, from (3.3.1),  $L^*$  is essentially a constant which depends only on  $\varphi(Z)$  and is therefore independent of the diffraction grating used in the experiment. Consequently, while the circumference length of the arriving photon ring is given by  $L=2\pi A$ , which is constant for all the elements in a given periodic table row and is initially very small, after smacking almost squarely onto the grating it is postulated the resulting shape is a much larger ring with an essentially constant circumferential length of  $L^*$ , which is a length that uniquely depends on the source element.

## 4. Photon Action after Contact with the Grating

### 4.1 Introduction

After the ring-like photon with a virtually constant circumferential length of  $L=2\pi A$  arrives at the grating and the resulting squashing action changes it to a ring-like shape with a postulated nearly constant circumferential value of  $L^*$ , it then slides toward a

slit, where it is assumed that it undergoes unraveling into a pipe-like shape and exits the grating with an unchanged length of  $L^*$ . These exiting photons then move toward a distant screen at a variable angle,  $\theta$ .

In Figure 1 below a specific special case is shown, where the exiting photons have a somewhat constant length of  $L^*$ . While the exit angle,  $\theta$ , is variable, the specific value chosen in the figure is  $\theta^*$ , which is a function of  $L^*$  and which will now be studied. In this

special case it is seen that the line drawn orthogonally from any given slit to the photon movement line on the immediate right of the slit intersects this line at a distance of  $L^*$ . That is, the specific exit angle of  $\theta^*$  in the figure is such that the orthogonal lines drawn from the grating slits to the individual ray lines on the right intersect them at successive distances of  $L^*$ . These intersections are shown in Figure 1 below for a given vertical height in the apparatus.

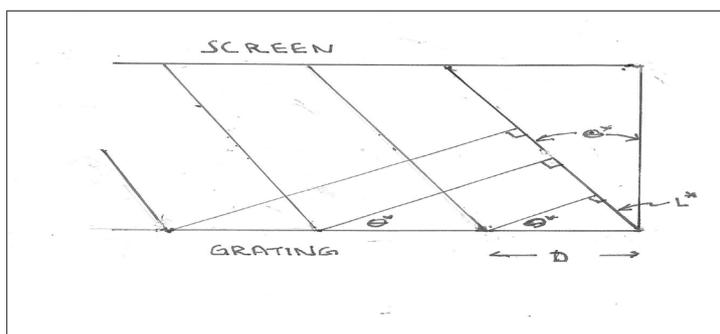


Figure 1. Diffraction Grating as Viewed from the Top

### 4.2 Explanation of the Linear Pattern Lines

Since both the arriving and exiting photons are shaped as atomic sized particles, the reason why they leave individual point marks on the screen when only a small number are involved is self-explanatory. The problem therefore lies with explaining the linear pattern lines which form when there are many emissions. It is reiterated that the exiting individual photons from the grating have been assumed to be in the shape of relatively long, atomic sized, spinning pipes with a somewhat constant length of  $L^*$ , where  $L^*$  depends on the source.

The dark lines in diffraction grating experiments can be explained from Figure 1. While the many photons move from the grating slits at various  $\theta$  angles, the particular value of  $\theta$  chosen in the figure is  $\theta^*$ , which has the following special property.

$$L^* = D \sin(\theta^*) \tag{4.2.1}$$

As  $D$  is very small in size, the individual path lines are very close together, so that they all reach the screen at essentially the same point, but not at the same time. From (4.2.1) the individual path lines at a given height have been divided into segments of photon length  $L^*$ , so that each of the segments can in theory contain one photon. If it so happened in an experiment that a fundamental dark line appeared on the screen at an angle of  $\theta^*$ , then the diffraction grating conclusion concerning the estimated value of the nonexistent wavelength, call it  $\lambda^*$ , would be as follows.

$$\lambda^* = D \sin(\theta^*) \tag{4.2.2}$$

Accordingly, if the first major dark line on the screen happened to appear at an angle  $\theta^*$ , then from the above analysis the calculated wavelength would be given by the following.

$$\lambda^* = L^* \tag{4.2.3}$$

It is reiterated that  $\lambda^*$  is the calculated, nonexistent wavelength value. It will now be theorized that the fundamental linear pattern lines will roughly appear at the specific angle  $\theta^*$ , as shown in Figure 1.

### 4.3 Proof that the Dark Lines Form at $\theta^*$

It is noted that the lines shown in Figure 1 are all essentially parallel. Also, the distances between the lines are so small that all the photons end up at essentially the same point on the screen for the given height, though not at the same time. Now consider two adjacent path lines in the figure. It is argued that any photon on the left line can mesh into the line on the right even if there is no immediate space available, given that a little shoving can be done. This is due to the fact that the usage spaces on the right line are always closely equal to one photon in length, so that available spaces are always in lengths of one photon. This is true even if there are many photons emanating from many slits merging into what is essentially a single line. However, it is important to note that this meshing is not possible in crowded situations if the different photon spaces are not closely equal to the length of one photon.

It is therefore argued that at an angle of  $\theta^*$  a series of dark lines will appear on the screen corresponding

to the exiting photon pipes from the slits when there are many exiting photons. The same holds true concerning when the rays emerge from the left sides of the slits rather than from the right sides shown in the figure. Thus, for example, this explains why in the case of sodium emissions there are two calculated values of  $\lambda^*$  which are extremely close together. Also, while the rays shown in the figure all emanate from the grating from every slit, they also could have come from separation distances of  $X=mD$ , where  $m$  is any integer.

From these arguments it is concluded that the diffraction grating patterns for photon experiments have been explained.

## 5. A Brief Look at Electron Emanations

It is assumed that electrons are very similar to photons, in the sense that they are microscopic particles in shape which enclose an electric field. Accordingly, it is argued the preceding analysis concerning photons essentially applies to electrons. Thus, an electron approaching a diffraction grating can be assumed to be a small, enclosed, electric field with a somewhat constant circumferential length of  $P$ . When it hits the grating, this length is squashed into a larger length,  $P^*$ , which is assumed to be relatively constant. Then, in a manner similar to the photons, this electric field particle slides toward a slit and then escapes out of it in the shape of a long thin pipe which has a somewhat constant length of  $P^*$ . At this point the analysis is virtually the same as in the case of photons, and linear pattern lines appear.

## 6. Conclusion

This work is primarily concerned with diffraction grating experiments on photons, but at its conclusion it is also shown that similar results are to be expected when electrons emerge from the source. The wave-particle paradox refers to the mysterious diffraction grating experimental results in which photons seem to be particles when only a few of them emerge from the grating, but also seem to be waves when the number is large. It is held that the photon particle corpuscle theory given in [1-5] which is used in this paper has inarguable experimental backing in that it leads to the derivation of Planck's constant, the photoelectric effect, and the structure of the periodic table. In this current work a theory underlying the reason for the wave-particle paradox for photons in diffraction grating experiments is given which is based on the photon particles theorized in [1-5] and the length,  $L^*$ , of the photons that emerge from the grating. It is shown here

that  $\lambda^*=L^*$ , where  $\lambda^*$  is the calculated experimental value of the nonexistent wavelength and  $L^*$  depends only on the source element and not on the grating. Accordingly, from this analysis a feasible explanation of the wave-particle paradox has been given. On the assumption it is valid, it is argued the wave-particle paradox is resolved. Also, from [6] photon particles are given greater gravitas in that it is shown that the wavelength results of diffraction grating experiments are erroneous. Lastly, it can be held that quantum mechanics was developed, at least in part, because of the need to explain the lack of radiation in an atom with orbiting electrons. This problem is inarguably resolved in [1-5].

Concerning future work, which is well-underway, a formula for the experimental wavelength value,  $\lambda^*$ , will be sought using the theory developed in this paper, so that the experimental wavelengths of photons will be known without the need to measure them.

## 7. References

1. Aucamp, D.C. (2023), "A Non-Radiating Atomic Electron Model with an Application to Molecular Structure and the Periodic Table", Open Access Journal of Physics(OAJP), V5(1), pp. 01-08.
2. Aucamp, D.C. (2023), "An Alternative to Quantum Theory, Photon Radiation, Entanglement, Photon Structure, the Wave-Particle Paradox, and Einstein's Photoelectric Effect", OAJP, V5(1), pp. 10-14.
3. Aucamp, D.C. (2023), "Proofs of the Law of Atomic Radii and the Atomic Numbers of the Noble Elements", OAJP, V5(1), pp. 15-17.
4. Aucamp, D.C. (2023), "A Disproof of Einstein's Photoelectric Contention That Maxwell Emissions are Photons, with an Application to the Resolution of the Wave-Particle Paradox", OAJP, V5(2), pp. 1-3.
5. Aucamp, D.C. (2024), "A Derivation of the Formula for Planck's Constant, the Photoelectric Effect, and the Details of the Photon Emission Process", OAJP, V8(1), pp. 1-5.
6. Aucamp, D.C. (2026), "A Proof that Diffraction Grating Experimental Wavelength Conclusions are in Error", OAJP, V8(2), pp. 1-3.
7. Bohr, Niels, (1913), "On the Constitution of Atoms and Molecules(3 papers): Part I, Part II, Part III", Philosophical Magazine 28.
8. Einstein, A. (1905), "Zur Elektrodynamik bewegter Körper", Annalen der Physik, 17, 891 (trans in The Principal of Relativity, Dover).
9. Feynman, R., (1963), "The Feynman Lectures on Physics", Vol 1, Addison-Wesley, Reading, Mass.