The Compton Wavelength and the Relativistic Compton Wavelength Derived from Collision-Space-Time*

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Abstract

In this paper, we show how one can find the Compton scattering formula and thereby also the Compton wavelength based on new concepts from collision-space time. This gives us the standard Compton wavelength, but we go one step forward and show how to find the relativistic Compton wavelength from Compton scattering as well. (That is, when the electron is also moving initially.) The original Compton formula only gives the electron's rest-mass Compton wavelength, or we could call it the standing electron's Compton wave.

Keywords: Compton wavelength, Compton scattering, moving electron.

1 Introduction

Recently Haug [1] has published a unified quantum gravity theory[1], which unifies gravity with quantum mechanics and relativity theory. In this theory, the Compton wavelength play a central role. It is therefore of interest to know if Compton scattering [3] is fully compatible with this theory and also if the observed Compton wave can be derived from this theory. We show in the section below that this is the case. We even go one step beyond Compton and derive a fully relativistic version. The standard Compton wave formula assumes the electron is standing still initially.

2 Compton Scattering under Collision-Space-Time Theory

We must have two equations; they are the following

$$p_1 + \bar{m}c = p_2 + \frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}} \tag{1}$$

and

$$\left(\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}\right)^2 = p_1^2 + p_2^2 - 2p_1p_2\cos\theta \tag{2}$$

This gives

*Thanks to Victoria Terces for helping me edit this manuscript.
[1]See also the working paper [2].

$$
\begin{aligned}
p_1 + \bar{m}c &= p_2 + \frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}} \\
(p_1 - p_2 + \bar{m}c)^2 &= p_1^2 + p_2^2 - 2p_1p_2\cos\theta \\
p_1^2 - 2p_1p_2 + p_2^2 + 2\bar{m}cp_1 - 2\bar{m}cp_2 &= p_1^2 + p_2^2 - 2p_1p_2\cos\theta \\
\bar{m}cp_2 - \bar{m}cp_1 &= p_1p_2(1-\cos\theta) \\
\frac{1}{p_1} - \frac{1}{p_2} &= \frac{1}{\bar{m}c}(1-\cos\theta) \\
\frac{l_p^2}{p_1} - \frac{l_p^2}{p_2} &= \frac{l_p^2}{\bar{m}c}(1-\cos\theta) \\
\lambda_1 - \lambda_2 &= \frac{l_p^2}{\bar{m}c}(1-\cos\theta)
\end{aligned} \tag{3}
$$

this is the well-known Compton scattering formula. Because $\frac{l_p^2}{\bar{m}c} = \frac{l_p^2}{\frac{l_p}{c}\frac{l_p}{\bar{\lambda}}c} = \bar{\lambda}$ (and also $\frac{\hbar}{mc}$) is the (reduced) Compton wavelength, or more precisely the rest wavelength of the Compton wavelength, we can rewrite the Compton scattering formula as

$$
\lambda_1 - \lambda_2 = \bar{\lambda}(1-\cos\theta) \tag{4}
$$

where $\lambda_{c,r}$ is the Compton wavelength of the particle at rest (the electron). The Compton wavelength is therefore indirectly measured by watching the change in wavelength in the photon used to scatter the electrons. However, Compton's formula, even if relativistic, assumes the electron that is scattered by the photon is itself at rest before the scattering.

If the electron is moving initially, Compton scattering is given by

$$
\begin{aligned}
p_1 + \frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}} &= p_2 + \frac{\bar{m}c}{\sqrt{1-\frac{v_2^2}{c^2}}} \\
\left(p_1 - p_2 + \frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}\right)^2 &= p_1^2 + p_2^2 - 2p_1p_2\cos\theta \\
p_1^2 - 2p_1p_2 + p_2^2 + 2\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}p_1 - 2\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}p_2 &= p_1^2 + p_2^2 - 2p_1p_2\cos\theta \\
\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}p_2 - \frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}p_1 &= p_1p_2(1-\cos\theta) \\
\frac{1}{p_1} - \frac{1}{p_2} &= \frac{1}{\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}}(1-\cos\theta) \\
\frac{h}{p_1} - \frac{h}{p_2} &= \frac{l_p^2}{\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}}(1-\cos\theta) \\
\lambda_1 - \lambda_2 &= \frac{l_p^2}{\frac{\bar{m}c}{\sqrt{1-\frac{v^2}{c^2}}}}(1-\cos\theta) \\
\lambda_1 - \lambda_2 &= \frac{l_p^2}{\frac{\frac{l_p}{c}\frac{l_p}{\bar{\lambda}}c}{\sqrt{1-\frac{v^2}{c^2}}}}(1-\cos\theta) \\
\lambda_1 - \lambda_2 &= \bar{\lambda}\sqrt{1-\frac{v^2}{c^2}}(1-\cos\theta)
\end{aligned} \tag{5}
$$

The relativistic Compton wavelength is therefore given by

$$
\bar{\lambda}\sqrt{1-\frac{v^2}{c^2}} = \frac{\lambda_1 - \lambda_2}{(1-\cos\theta)} \tag{6}
$$

In other words, we only need to measure the photon's wavelength before or after the scattering and the angle θ to know the relativistic Compton wavelength. This means the relativistic Compton wavelength also can be written as

$$\bar{\lambda}_r = \frac{l_p^2}{\frac{\bar{m}c}{\sqrt{1-v^2/c^2}}} = \bar{\lambda}\sqrt{1-\frac{v^2}{c^2}} \tag{7}$$

or if using the traditional kg mass, we have (see

$$\bar{\lambda}_r = \frac{\hbar}{\frac{mc}{\sqrt{1-v^2/c^2}}} = \bar{\lambda}\sqrt{1-\frac{v^2}{c^2}} \tag{8}$$

Actually, Compton [3] did not derive a Compton wavelength for the case where the electron is moving. The fully relativistic Compton wavelength is central in collision-space-time, and also indirectly for many derivations in standard physics. As we have pointed out in our new quantum gravity theory, it is the Compton wavelength that is the true matter wave; the de Broglie wave is merely a mathematical derivative of the Compton wave. The fact that standard physics thinks the de Broglie wave [4, 5] is a true matter wave has caused much confusion in interpretations of modern physics, and one of several reasons why it has not been possible to unify gravity with quantum mechanics yet. Naturally, one can also derive the relativistic Compton wave when using the kg definition of mass instead, as we have recently shown in a similar paper [6].

3 Conclusion

We have shown that the Compton wavelength, as well as the relativistic Compton wavelength, easily can be derived from the new unified quantum gravity theory known as collision-space-time. It can also be observed by experiments, which has been done many times. The Compton wavelength plays a central role in collision-space-time; for more on this, see our unified collision-space-time paper .

References

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