Chapter 15

Generally Covariant Quantum Mechanics

by
Myron W. Evans,
Alpha Foundation's Institutute for Advance Study (AIAS).
(emyrone@oal.com, www.aias.us, www.atomicprecision.com)

"Dedicated to the Late Jean-Pierre Vigier"

Abstract

In order to make quantum mechanics compatible with general relativity the Heisenberg uncertainty principle is given a generally covariant (or objective) and causal interpretation. The fundamental conjugate variables are shown to be quantities such as momentum density, angular momentum density and energy density in general relativity instead of quantities such as momentum, angular momentum and energy in special relativity. The generally covariant interpretation of quantum mechanics given in this paper agrees with the repeatable and reproducible experimental data of Croca et al. and of Afshar, data which show that the conventional Heisenberg uncertainty principle is qualitatively incorrect, and with it all the arguments of the Copenhagen school throughout the twentieth century. The correctly objective interpretation of quantum mechanics is given by the deterministic school of Einstein, de Broglie, Vigier and others. This is a direct result of the Evans unified field theory.

Key words: Evans unified field theory; generally covariant Heisenberg equation and Heisenberg uncertainty principle.

15.1 Introduction

Generally covariant quantum mechanics does not exist in the standard model because general relativity is causal and objective, the Copenhagen interpretation of quantum mechanics is acausal and subjective. This is the central issue of the great twentieth century debate in physics between the Copenhagen and deterministic schools of thought, an issue which is resolved conclusively in favor of the deterministic school by the Evans unified field theory [1]– [19]. At the root of the debate is the Heisenberg equation of motion [20], which in its simplest form is a rewriting of the operator equivalence condition of quantum mechanics:

$$p^\mu = i\hbar\partial^\mu. \tag{15.1}$$

Eq.(15.1) is an equation of special relativity where:

$$p^\mu = \left(\frac{En}{c}, \mathbf{p}\right) \tag{15.2}$$

is the energy momentum four vector, and:

$$\partial^\mu = \left(\frac{1}{c}\frac{\partial}{\partial t}, -\nabla\right). \tag{15.3}$$

Here En denotes energy, c is the vacuum speed of light, $\mathbf{p}$ is the linear momentum,$\hbar$ is the reduced Planck constant, and the partial four derivative ∂^μ is defined in terms of the time derivative and the ∇ operator in Eq.(15.3).

In Section 15.2 the operator equivalence (15.1) is rewritten as the Heisenberg equation of motion [20]. The Heisenberg uncertainty principle is a direct mathematical consequence of the Heisenberg equation and therefore is a direct mathematical consequence of Eq.(15.1). However, recent reproducible and repeatable experimental data [21]– [23] show that the Heisenberg uncertainty principle is violated completely in several independent ways. This means that the principle as it stands is completely incorrect, i.e. by many orders of magnitude. For example in the various experiments of Croca et al. [21] the principle is incorrect by nine orders of magnitude even at moderate microscope resolution. As the resolution is increased it becomes qualitatively wrong, i.e. the conjugate variable of position and momentum appear to commute precisely within experimental precision. The uncertainty principle states that if the conjugate variables are for example the position x and the component p_x of linear momentum then [20]:

$$\delta x \delta p_x \geq \frac{\hbar}{2}. \tag{15.4}$$

This means that the δx and δp_x variables cannot commute and the conventional Copenhagen interpretation is that they cannot be simultaneously observable [20] and cannot be simultaneously knowable. This subjective assertion violates causality and general relativity (i.e. objective physics) and has led to endless confusion for students. The experimental results of Croca et al [21] show that:

$$\delta x \delta p_x = 10^{-9}\frac{\hbar}{2} \tag{15.5}$$

at moderate microscope resolution. As the latter is increased, the experimental result is:

$$\delta x \delta p_x \longrightarrow 0 \tag{15.6}$$

in direct experimental contradiction of the uncertainty principle (15.4).

In the independent series of experiments by Afshar [22], carried out at Harvard and elsewhere, the photon and electromagnetic wave are shown to be simultaneously observable, indicating independently that the position and momentum or time and energy conjugate variables commute precisely to within experimental precision. In a third series of independent experiments [23], on two dimensional materials near absolute zero, the Heisenberg uncertainty principle again predicts diametrically the incorrect experimental result to within instrumental precision. Each type of experiment [21]– [23] is independently reproducible and repeatable to high precision.

In Section 15.3 this major crisis for the standard model is resolved straightforwardly through the use of the appropriate densities of conjugate variables in general relativity. The experimentally well tested Eq.(15.1) is retained, but the fundamental conjugate variables are carefully redefined within the generally covariant Evans unified field theory, which derives generally covariant quantum mechanics from Cartans differential geometry [1]– [19] for all radiated and matter fields. The result is a generally covariant quantum mechanics in agreement with the most recent experiments [21]– [23] and philosophically compatible with the causal and objective Evans unified field theory. The latter denies subjectivity and acausality in natural philosophy.

15.2 A Simple Derivation Of The Heisenberg Equation Of Motion

In its simplest form the Heisenberg equation of motion [20] is:

$$[x, p_x]\,\psi = i\hbar\psi \tag{15.7}$$

where ψ is the wave-function. Eq.(15.7) means that the commutator:

$$[x, p_x] = xp_x - p_x x \tag{15.8}$$

operates on the wave-function. From Eq.(15.1):

$$p_x = -i\hbar\frac{\partial}{\partial x} \tag{15.9}$$

and so p_x becomes a differential operator acting on ψ . The position x is interpreted as a simple multiple, i.e. x multiplies anything that follows it. Using the Leibnitz Theorem and these operator rules it follows that:

$$\begin{aligned}
[x, p_x]\,\psi &= (xp_x - p_x x)\,\psi \\
&= x\,(p_x\psi) - p_x\,(x\psi) \\
&= x\,(p_x\psi) - (p_x x)\,\psi - x\,(p_x\psi) \\
&= -\,(p_x x)\,\psi \\
&= \left(i\hbar\frac{\partial x}{\partial x}\right)\psi \\
&= i\hbar\psi
\end{aligned} \tag{15.10}$$

and it is seen that the Heisenberg equation is a rewriting of Eq.(15.1), a component of which is Eq.(15.9). Using standard methods [20] we obtain the famous Heisenberg uncertainty principle

$$\delta x \delta p_x \geq \frac{\hbar}{2} \tag{15.11}$$

from Eq.(15.9) and thus from Eq.(15.1), the famous wave particle duality of de Broglie. This derivation is given to show that the uncertainty principle, which has dominated thought in physics for nearly a century, is another statement of the de Broglie wave particle duality.

The subjective and acausal interpretations inherent in the Heisenberg uncertainty principle were rejected immediately by Einstein and his followers, as is well known, and later also rejected by de Broglie and his follower Vigier. These are the acknowledged masters of the deterministic school of physics in the twentieth century. The data [21]– [23] now show with pristine clarity that the deterministic school is right, the Copenhagen school is wrong. It is important to realize that the deterministic school accepts quantum mechanics, i.e accepts Eq.(15.1) but rejects the INTERPRETATION of Eq.(15.7) by the Copenhagen school. The ensuing debate became protracted due to a lack of a unified field theory and a lack of experimental data. Both are now available.

15.3 The Generally Covariant Heisenberg Equation

Neither school discovered the reason why Eq.(15.11) is so wildly incorrect. With the emergence of the Evans unified field theory (2003 to present), more than a hundred years after special relativity (1892 - 1905), we now know why the experiments [21]– [23] give the results they do. The error in the Copenhagen school's philosophy is the obvious one - the subjective reliance on conjugate variables which are not correctly objective (generally covariant). They are not DENSITIES, as required by the fundamentals of general relativity and the Evans unified field theory. In order to develop a correctly objective quantum mechanics the momentum p_x has to be replaced by a momentum density $\overline{p_x}$ and the angular momentum $\hbar$ by an angular momentum density $\overline{\hbar}$. The reason is that the fundamental law of general relativity [1]– [19] is:

$$R = -kT \tag{15.12}$$

where T is the scalar valued canonical energy-momentum density, R is a well defined scalar curvature, and k is Einstein's constant. In the rest frame T reduces to the mass density of an elementary particle:

$$T \rightarrow \frac{m}{V_0} \tag{15.13}$$

and within a factor c^2 this is the rest energy density:

$$\overline{En_0} = \frac{mc^2}{V_0}. \tag{15.14}$$

Here V_0 is the Evans rest volume

$$V_0 = \frac{\hbar^2 k}{mc^2} \tag{15.15}$$

where m is the elementary particle mass.

Define the experimental momentum density for a given instrument by:

$$\overline{p_x} = \frac{p_x}{V} \tag{15.16}$$

and define the fundamental angular momentum or action density by:

$$\overline{\hbar} = \frac{\hbar}{V_0}. \tag{15.17}$$

Here V is a macroscopic volume defined by the apparatus being used, or the volume occupied by the momentum component p_x. The quantum $\overline{\hbar}$ is the fundamental density of the reduced Planck constant:

$$\overline{\hbar} = \frac{mc^2}{\hbar k} \tag{15.18}$$

i.e. the rest energy divided by the product of $\hbar$ and k. Eq(15.18) means that the quantum of action occupies the Evans rest volume V_0. For any particle, including the six quarks, the photon and the neutrinos, the graviton and the gravitino. This deduction follows from the special relativistic limit of the Evans wave equation for one particle is [1]– [19]:

$$kT = \frac{km}{V_0} = \frac{m^2c^2}{\hbar^2}. \tag{15.19}$$

In general relativity therefore Eq.(15.9) becomes:

$$\overline{p_x} = -i\overline{\hbar}\frac{\partial}{\partial x} \tag{15.20}$$

i.e.:

$$\overline{p_x}\psi = -i\overline{\hbar}\frac{\partial\psi}{\partial x}. \tag{15.21}$$

Eq.(15.9), which is precisely verified experimentally in quantum mechanics, is therefore the same as:

$$\overline{p_x} = -i\frac{V_0}{V}\overline{\hbar}\frac{\partial}{\partial x} \tag{15.22}$$

which is a special case of the fundamental wave particle duality in general relativity:

$$\overline{p}^\mu = i\frac{V_0}{V}\overline{\hbar}\partial^\mu. \tag{15.23}$$

The generally covariant Heisenberg equation is therefore:

$$[x, \overline{p_x}] = i\frac{V_0}{V}\overline{\hbar} \tag{15.24}$$

and the fundamental conjugate variables of generally covariant quantum mechanics are x and $\overline{p_x}$. The fundamental quantum is $\overline{\hbar}$.

Experimentally for a macroscopic volume V:

$$V_0 \ll V \tag{15.25}$$

and so

$$[x, \overline{p_x}] \sim 0 \tag{15.26}$$

which implies

$$\delta x \sim 0, \quad \delta\overline{p_x} \sim 0 \tag{15.27}$$

is quite possible experimentally. Therefore what is being observed experimentally in the Croca and Afshar experiments is $\overline{p_x}$ and not p_x, and $\overline{\hbar}$ and not $\hbar$. This deduction means that a particle coexists with its matter wave, as inferred by de Broglie. For electromagnetism this coexistence has been clearly observed by Afshar [22] in modified Young experiments which are precise, reproducible and repeatable.

The fundamental conjugate variables are therefore position and momentum density, or time and energy density, and not position and momentum, or time and energy as in the conventional theory [20] and as in the Copenhagen interpretation. The wave function is always the tetrad, and this is always defined causally and objectively by Cartans differential geometry [1]– [19]. There is no uncertainty or acausality in geometry and none in physics. The fundamental wave equation of generally covariant quantum mechanics is the Evans wave equation [1]– [19]:

$$(\Box + kT)\, q^a{}_\mu = 0 \tag{15.28}$$

which reduces to all other wave equations of physics, and thence to other equations of physics in well defined limits.

Acknowledgments The British Government is thanked for a Civil List Pension. Franklin Amador is thanked for meticulous typesetting. Sean MacLachlan and Bob Gray are thanked for setting up the websites www.aias.us and www.atomicprecision.com. The Ted Annis Foundation, Craddock Inc, Prof. John B. Hart and several others are thanked for funding. The staff of AIAS and many others are thanked for many interesting discussions, 2003 to present.

Bibliography

[1] M. W. Evans, *Found. Phys. Lett.*, **16**, 367, 507 (2003).

[2] M. W. Evans, *Found. Phys. Lett.*, **17**, 25, 149, 267, 301, 393, 433, 535, 663 (2004).

[3] M. W. Evans, *Found. Phys. Lett.*, **18**, 259 (2005).

[4] M. W. Evans, *Generally Covariant Unified Field Theory: the Geometrization of Physics* (in press 2005, preprints on www.aias.us and www.atomicprecision.com).

[5] L. Felker, *The Evans Equations of Unified Field Theory* (in press 2005, preprints on www.aias.us and www.atomicprecision.com).

[6] M. W. Evans, The Objective Laws of Classical Electrodynamics, the Effect of Gravitation on Electromagnetism, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[7] M. W. Evans, First and Second Order Aharonov Bohm Effects in the Evans Unified Field Theory, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[8] M. W. Evans, The Spinning of Spacetime as Seen in the Inverse Faraday Effect, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[9] M. W. Evans, On the Origin of Polarization and Magnetization, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[10] M. W. Evans, Explanation of the Eddington Experiment in the Evans Unified Field Theory, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[11] M. W. Evans, The Coulomb and Ampère Maxwell Laws in the Schwarzschild Metric: A Classical Calculation of the Eddington Effect from the Evans Field Theory, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[12] M. W. Evans, Generally Covariant Heisenberg Equation from the Evans Unified Field Theory, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[13] M. W. Evans, Metric Compatibility and the Tetrad Postulate, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[14] M. W. Evans. Derivation of the Evans Lemma and Wave Equation from the First Cartan Structure Equation, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[15] M. W. Evans, Proof of the Evans Lemma from the Tetrad Postulate, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[16] M. W. Evans, Self-Consistent Derivation of the Evans Lemma and Application to the Generally Covariant Dirac Equation, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[17] M. W. Evans, Quark Gluon Model in the Evans Unified Field Theory, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[18] M. W. Evans, The Origin of Intrinsic Spin and the Pauli Exclusion Principle in the Evans Unified Field Theory, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[19] M. W. Evans, On the Origin of Dark Matter as Spacetime Torsion, *J. New Energy* Special Issue (2005, preprint on www.aias.us and www.atomicprecision.com).

[20] P. W. Atkins, *Molecular Quantum Mechanics* (Oxford Univ Press, 2nd ed., 1983).

[21] J. R. Croca, *Towards a Non-Linear Quantum Physics* (World Scientific, 2003).

[22] M. Chown, *New Scientist*, **183**, 30 (2004).

[23] B. Schechter, *New Scientist*, pp.38 ff (2004).