Generally covariant quantum mechanics does not exist in the standard model but is required by the phenomenon of precision in both of general relativity and of quantum mechanics. In order to construct such a theory the Heisenberg uncertainty principle must be made generally covariant. The standard uncertainty principle is illustrated by:

\[ [x, p_x] \psi = i \hbar \phi \quad - (1) \]

where:

\[ p_x = -i \hbar \frac{\partial}{\partial x} \quad - (2) \]

Eq. (1) is simply a restatement of the operator equivalence (2). Eq. (1) is derived as follows:

\[ [x, p_x] \psi = (xp_x - p_x x) \psi \]

\[ = x(p_x \psi) - p_x (x \psi) \]

\[ = x(p_x \psi) - (p_x x) \psi - x(p_x \psi) \]

\[ = - (p_x x) \psi \]

\[ = -i \hbar \frac{\partial}{\partial x} \psi \]

\[ = i \hbar \frac{\partial}{\partial x} \phi \quad - (3) \]
Standard arguments show that:

\[ S_x S_p \geq \frac{\hbar}{2} \quad - (4) \]

and eq. (4) is the standard expression of the Heisenberg uncertainty principle. 

Eqs. (1) and (4) are direct mathematical consequences of eq. (2).

Recent experimental results of Cucca et al., using advanced microscopy, show that for moderate resolution:

\[ S_x S_p \approx 10^{-9} \hbar \quad - (5) \]

Ref. [2] reinforces the Heisenberg uncertainty principle: eq. (4) is violated experimentally by at least two orders of magnitude. At high resolution, experimental results show that:

\[ S_x S_p \rightarrow 0 \quad - (6) \]

It is complete contradiction to the standard model.
The results produce a crisis in the standard model and lead to the abandonment of the Heisenberg uncertainty principle.

The error in the Copenhagen School's philosophy is traced to two notes to the fact that the fundamental post of equivalence (3) is not generally covariant. In order to make it generally covariant, momentum per has to be replaced by a momentum density and angular momentum by an angular momentum density. The reason is that the fundamental law of general relativity is:

\[ R = -kT \quad (7) \]

where \( T \) is a canonical energy-momentum density. In the first frame, \( T \) reduces to a mass density:

\[ T \rightarrow \frac{m}{V_0} \quad (8) \]

and within a factor \( c^2 \) this is the rest energy density. Here \( V_0 \) is the light-cost volume:

\[ V_0 = \frac{E^2 R}{mc^2} \quad (9) \]

where \( m \) is the elementary particle mass.
Define momentum density $\rho \text{ kg m}^{-2} \text{ s}^{-1}$. Let $\rho = \frac{P_{x}}{V}$.\hfill \hbox{(10)}

and pressure momentum density $\tau \text{ kg m}^{-2} \text{ s}^{-2}$. Let $\tau = \frac{\rho}{V_{o}}$.\hfill \hbox{(11)}

Here $V$ is the volume of the apparatus, or the volume occupied by the momentum $P_{x}$. The $\rho$ is the density of the reduced Planck constant. Eq. (11) means that the quantum of a particular volume $V_{0}$, of Evans's first volume, occupies a volume $V_{0}$ of the second volume. This follows from the equivalence of the two volume equations:

$$kT = \left(\frac{nC_{s}}{\rho}\right) = \frac{k}{\rho} \frac{V_{0}}{k_{B}}.\hbox{ (12)}$$

In the limit of special relativity, the quantum $\hbar$ is defined by the volume $V_{0}$. In general relativity, where Eq. (3) becomes:

$$\frac{P_{x}}{\rho} = \frac{1}{k} \frac{\partial}{\partial x} = \frac{1}{k} \frac{\rho}{\partial x}.\hbox{ (14)}$$
Eqs. (2), which make very precisely a quantum mechanics, is therefore the same as:

$$\tilde{p}_x = -i \left( \frac{V_0}{V} \right) \tilde{x} \frac{\partial}{\partial x} - (15)$$

which is a special case of:

$$\tilde{p}^a = i \left( \frac{V_0}{V} \right) \tilde{x}^a - (16)$$

The Heisenberg equations are generally correct for the form:

$$[x, \tilde{p}_x] = i \left( \frac{V_0}{V} \right) \tilde{x} - (17)$$

and the fundamental conjugate variables are $x$ and $\tilde{p}_x$. The fundamental quantum is therefore $\tilde{x}$, and not $\tilde{p}$.

Experimentally, for a macroscopic volume $V$:

$$V_0 \ll V - (18)$$

and so:

$$[x, \tilde{p}_x] \approx 0 - (19)$$

$$\Rightarrow \delta x = 0, \delta \tilde{p}_x = 0 - (20)$$

is quite possible experimentally.
This means that a particle and a wave can co-exist experimentally. From the point of view of de Broglie and Einstein, for electromagnetic fields, quantum effects have been observed by appara at Harvard and elsewhere in quite simple experiments (New Scientist, 2004).

The fundamental conjugate variables are density, position, and momentum, and energy density. The wave function is always causal, and is always governed by the causal and objective. Even wave equation:

$$i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar}{2m} \nabla^2 \psi - V \psi$$  \hspace{1cm} (21)$$

Eqn (21) is the fundamental wave equation of generally covariant quantum mechanics.