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The inner bound of quantum spacetime

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Abstract

We address the connection between the UNCERTAINTY PRINCIPLE and
the WIGNER FUNCTION. In addition we highlight that an orthogonal
spatial dimension is needed in order to have both information
from the momentum and the position simultaneously.

keywords: uncertainty principle, Wigner function, spacetime, quantum gravity

The most updated version of this white paper is available at

https://osf.io/6zf3n/download

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The uncertainty principle and the Wigner function

1. The uncertainty principle shows that energy and time, for example, are inversely proportional, i.e., $\Delta E \Delta t \geq \frac{\hbar}{2}$.

2. The relation from (1) gives us poor information on how energy is mathematically related to time.

3. The same holds for position x and momentum p, $\Delta x \Delta p \geq \frac{\hbar}{2}$.

4. The Wigner function contains more information, for instance, about the bounds of x and p, imposed by the quantum spacetime.

5. Plots of the Wigner function can be found here [1].

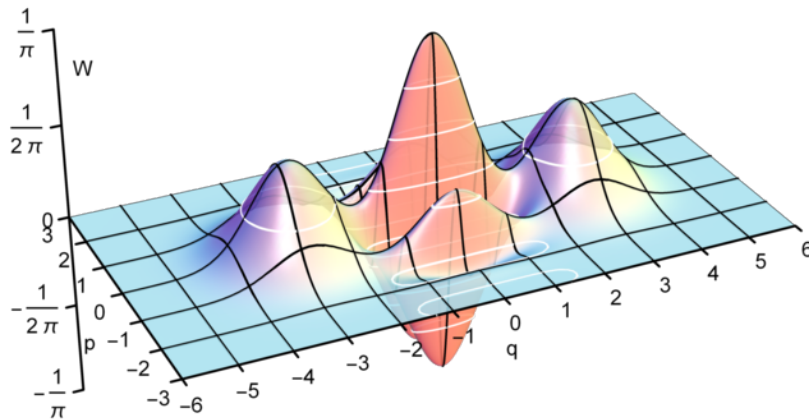6. It looks like a Gaussian in three dimensions (see Fig. 1).

Figure 1: Wigner function of a specific quantum state [2].

Ortogonal spatial dimension

7. The Wigner function is defined as [1]

$$W(x,p) = \frac{1}{h} \int e^{-ipy/\hbar} \psi(x+y/2)\psi^*(x-y/2)dy.$$

8. Note that Wigner added an "ortogonal dimension" y in the argument of the wavefunction ψ.

9. y is a dimension of space since it adds with the position x.

Final Remarks

10. **Wigner function** is of paramount importance since it **adds mathematical knowledge** to the _inner structure_ of **quantum spacetime**.

11. Wigner function is a generalization of the uncertainty principle.

12. What is the mathematical connection between the _Heisenberg uncertainty relation_ and the _Wigner function_?

13. In other words, _how does the uncertainty principle arise from the Wigner function?_

14. We know from special relativity that the orthogonal direction of space is Lorentz invariant.

15. Similarly, in quantum mechanics, a spatial dimension orthogonal to the wavefunction provides accurate information about the variables canonically conjugated (such as p and x) bounded by the uncertainty principle.

Open Invitation

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Join the **Open Quantum Collaboration**.
Send your contribution to `mplobo@uft.edu.br`.

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The **latex file** for this *white paper* together with other *supplementary files* are available in [5].

Ethical conduct of research

This original work was pre-registered under the OSF Preprints [6], please cite it accordingly [7]. This will ensure that researches are conducted with integrity and intellectual honesty at all times and by all means.

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Agreement

16. <u>All authors</u> **agree** with [4].

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