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Relativistic Wigner Operator and Its Distribution

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Abstract

It has been proved that the Wigner operator which results from the quantum - mechanical foundation of Bopp and Kubo in phase space, admits as eigenvalues the defference of the eigenvalues of two equivelant Shrödinger equations and as eigenfunction the well known Wigner distribution function.

$$\left[\mathcal{H}(\hat{P},\hat{Q})-\mathcal{H}(\hat{P}^*,\hat{Q}^*)\right]F(p,q)=i\hbar\frac{\partial}{\partial t}F(p,q)$$

$$\hat{P}=p-\frac{i\hbar}{2}\frac{\partial}{\partial q} \qquad \hat{Q}=q+\frac{i\hbar}{2}\frac{\partial}{\partial p} \qquad \hat{P}^*=p+\frac{i\hbar}{2}\frac{\partial}{\partial q} \qquad \hat{Q}^*=q-\frac{i\hbar}{2}\frac{\partial}{\partial p}$$

In this paper we apply this method to the relativistic case and we find that the eigenvalues are again the defference of the eigenvalues of two equivelant Dirac equations.

The eigenfunction is a 4×4 matrix with elements Wigner type distribution functions, namely

$$F_{ij}(p,q)=\int_{\infty}^{-\infty}\exp\{(i/\hbar)pq'\}\Psi_i(q-q'/2)\Psi_j^*(q+q'/2)dq'$$

where $\Psi_i(q)$ are the four Dirac's spinors.