Dedication

This thesis is dedicated to all of my family.

My friends…

*Everyone shares the interest in studying in the field Quantum mechanics***.**

Acknowledgement

All thanks are to Allah the Almighty for giving me the blessing and the strength to complete this work. I would like to express my sincere thanks to Prof. Dr: Mohammed Ali Basheir , who supervised this study, for his willing guidance and informative reviews and comments that contributed to the success of this work. I am truly grateful to him for his encouragement and help. I would like to thank my co supervisor Dr: Emad eldeen Abdallah Abdalrahim who participated in this study for his cooperation.

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Abstract

This study is mainly focused on the alternative version of Heisenberg uncertainty relation.

We have shown the separation of the total angular momentum of the electromagnetic field into its orbital and spin parts. It is dictated by quantum mechanics of photons reproduces. Therefore, the results are derived from the proprieties of Maxwell fields by Darwin. Then, we deal with the uncertainty relation for photons. The uncertainty relation was obtained as a sharp inequality by using the energy distribution on space. The relation we obtain here is an alternative to the one given by Heisenberg by the use of the position of the center of the energy operator. The fact that the components of the center is non commutative affected the right hand side of the Heisenberg inequality. But this is resolved by the increase of the photon energy.

الخلاصة

تتمركز هذه الدراسة مجملا فى دراسه النسخة البديلة لعدم التيقن لهايزنبرج.

في هذا الدراسة عرضنا الفصل لكمية الحركة الكلية الزاوية للفضاء الكهرومغناطيسي في الاجزاء المدارية واللولبية والتي تمت اعادة انتاجها من خلال ميكانيكا الكم للفوتون . وكانت النتائج مستمدة من خصائص حقول ماكسويل بواسطة داروين . ثم تناولنا دراسة عدم التيقن للفوتونات . وتم الحصول علي علاقة عدم التيقن باستخدام توزيع الطاقة في الفضاء . العلاقة المذكورة هنا هي بديل لعلاقة قدمت من هايزنبيرج باستخدام موقع وسط عامل الطاقة . حقيقة العناصر المكونة للمركز غير التبادلي اثرت علي الجانب الايمن لمتباينة هايزنبيرج وتم التعامل مع هذا التاثير بزيادة طاقة الفوتون.

Introduction:

In quantum mechanics we find that there are two types of angular momentum. These include orbital angular momentum L and spin angular momentum S. In addition, we can form total angular momentum, the combination $L + S$. It turns out that all types of angular momentum have certain properties in common; therefore we can study a "generalized" angular momentum, which we label J. We have already known the commutation relations satisfied by the components of orbital angular momentum. It turns out these are characteristic of all types of angular momentum, so we restate them here for J $[J_x, J_y] = i\hbar J_z$, $[J_y, J_z] = i\hbar J_x$, $[J_z, J_x] = i\hbar J_y$, which defines in classical physics as $\vec{L} = \vec{r} \times \vec{p}$ where $\vec{r}$ is the displacement vector from the origin and $\vec{p}$ is the linear momentum [36]. Our study here aims to discuss the total angular momentum and its separation into orbital and spin part of light beside Heisenberg uncertainty relation. To discuss these two things we separated our thesis into five parts.

Firstly, we study the From Polarized Light to Quantum Theory, which contains the polarization of light waves, Complex vector spaces, and some notations and definitions of it, Basis and Dimension, Completeness and Hilbert spaces, in section two we start with Linear Operators, Adjoint and Hermitean Operators, Eigenvectors, Eigenvalues and the Spectral Theorem, Functions of Operators, we end this part by Operators with continuous spectrum and The momentum operator, in addition The position representation of the momentum operator and the commutator between position and momentum.

Secondly we study On The Angular Momentum Of Photons, which contains inside four items the first one is introduction to the angular momentum of photons, From transversality to the operator of correlation, IDOF and its correlation with the momentum, and end this part by Sam is aligned with the wavevector direction.

Then, our study is going to discuss the third part in title Canonical separation of angular momentum of light into its orbital and spin parts, which discussed Quantum mechanics of photons, Electromagnetic field, Separation of angular momentum, and in last we introduced Conclusions to this part.

Heisenberg uncertainty relations for photons are our study to this part and our main goal of this thesis, inside of it we discussed Relativistic uncertainty relations,

Uncertainty relation for the product of $\langle \hat{R} \cdot \hat{R} \rangle$ and $\langle \hat{P} \cdot \hat{P} \rangle$, Uncertainty relation for the product of ΔR^2 *and* ΔP^2 and photon beams, and the Conclusions for this part.

Finally, we end this thesis by Axiomatic geometrical optics**,** which have inside Geometric Phases in Physics, Geometrical representation of angular momentum coherence and Squeezing, Axiomatic geometrical optics, Minkowski controversy, and the last one is Linear waves (Abraham Representation).

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