NONCLASSICAL PROPERTIES OF Q—DEFORMED SUPERPOSITION LIGHT FIELD STATE

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Abstract

In this paper, the squeezing effect, the bunching effect and the anti—bunching effect of the superposition light field state which involving q—deformation vacuum state |o> and q—Glauber coherent state |z> are studied, the controllable q—parameter of the squeezing effect, the bunching effect and the anti—bunching effect of q—deformed superposition light field state are obtained.

1 Introduction

In recent years people have made progress in the research of some concrete physical problem using quantum groups SU_q (2), Quantum algebra has been realized by using q—oscillator and the parametrized Fock state |n>q was obtained too. From this q—Glauber coherent state |n>q was introduced. Hao Sanjyu[1] showed that the coherent degree can be controlled by q—deformation parameter. Zhu Chongxu[1] showed that some quantum statistical properties of q—even—odd coherent state can be controlled by q—parameter.

We studied the squeezing effect of q—deformed superposition light field which involving q—deformation vacuum state |o> and q—Glauber Coherent state |z>. The results showed that the squeezing effect, the bunching effect and the anti—bunching effect can be controlled by q—parameter.

2 Nonclassical properties of q—deformed superposition Light field state.

The q—deformed superposition light field state is

| _ > = a | > + b | z >

where

| z > = q_i^{|a|} | [z] >

Z = Re{"a",i} , \( \alpha = \beta = \beta e^{i\phi} \)

| [x] > = q^{x/2} - q^{-x/2} (x \neq 1) \quad \epsilon_i^x = \frac{z^x}{(x!)^{1/2}}

The normalization condition is

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2.1 The squeezing effect of $q-$deformed superposition light field state

The two orthogonal components of $q-$deformed electromagnetic field are defined as

$$Y_1 = \frac{1}{2} (a_+ + a_-), Y_2 = \frac{1}{2} (a_+ - a_-)$$

(6)

where $a_-$ is $q-$annihilation operator and $a_+^-$ is $q-$creation operator. Because of $[Y_1, Y_2] = \frac{1}{2} [a_-, a_+]$, so we have the uncertainty relation.

$$\langle (\Delta Y_1)^2 \rangle \langle (\Delta Y_2)^2 \rangle \geq \frac{1}{4} |\langle [Y_1, Y_2] \rangle|^2$$

(7)

If the squeezing exists, then we have

$$F_i = \langle (\Delta Y_i)^2 \rangle - \frac{1}{4} \leq 0 \quad (i = 1, 2)$$

(8)

For $q-$deformed superposition light field state, we have

$$\langle \psi | a_\pm a_\pm^\dagger | \psi \rangle = (\alpha^* \langle 0 | + \beta^* \langle Z |) a_\pm a_\pm^\dagger (a|0 \rangle + \beta |Z \rangle$$

(9)

$$= |\alpha|^2 + \beta^* \alpha e^{\frac{1}{2} i |Z|^2} + |\beta|^2 e^{-\frac{1}{2} i |Z|^2} + \sum \frac{|Z|^2}{n} \delta_{n,1} [n + 1]$$

(10)

$$\langle \psi | a_\pm a_\pm | \psi \rangle = (\alpha^* \langle 0 | + \beta^* \langle Z |) a_\pm^\dagger a_\pm (a|0 \rangle + \beta |Z \rangle$$

(11)

$$= Z \beta^* \alpha e^{\frac{1}{2} i |Z|^2} + |\beta|^2 Z$$

(12)

$$\langle \psi | a_\pm^2 | \psi \rangle = (\alpha^* \langle 0 | + \beta^* \langle Z |) a_\pm^2 a_\pm (a|0 \rangle + \beta |Z \rangle$$

(13)

$$= \beta^* \alpha Z^2 e^{-\frac{1}{2} i |Z|^2} + |\beta|^2 Z^2$$

(14)

From (8) - (14), we can have

$$F_1 = \frac{1}{4} \{ \langle a_\pm^2 \rangle + \langle a_\pm^4 \rangle + \langle a_\pm^2 a_\pm \rangle + \langle a_\pm^4 a_\pm \rangle - (\langle a_\pm^2 \rangle + \langle a_\pm^4 \rangle)^2 \} - \frac{1}{4}$$

(15)

$$= \frac{1}{4} \left[ e^{\frac{1}{2} i R_1 R_2} \cos (\theta_2 + 2 \phi - \theta_1) + \frac{1}{2} \cos (R_1 R_2 + 2 \phi) + \frac{1}{2} \cos (R_1 R_2) \right]$$

$$= \frac{1}{4} \left[ -e^{-\frac{1}{2} i R_1 R_2} \cos (\theta_2 - 2 \phi - \theta_1) - \frac{1}{2} \cos (R_1 R_2 + 2 \phi) + \frac{1}{2} \cos (R_1 R_2) \right]$$

(16)

It is clear $F_1$ and $F_2$ are periodic function of $q$. Numerical valve calculating showed that $Y_1$ and $Y_2$ may be more than zero and less than zero accompanying the variation of $q$. This result shows that the generally squeezing may exist and can be controlled by $q$.

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2.2 The bunching effect, the anti-bunching effect of q-deformed superposition light field state

For q-deformed superposition light field state, we have

\[ \langle \psi | a_r^\dagger a_r^\dagger | \psi \rangle = |\beta|^2 |Z|^4 \]  

\[ g_r^{(2)}(0) = \frac{\langle \psi | a_r^\dagger a_r^\dagger | \psi \rangle}{\langle \psi | a_r^\dagger a_r^\dagger | \psi \rangle^2} = \frac{|\beta|^2 |Z|^4}{|\beta|^4 |Z|^4} = \frac{1}{r_1^2} = \frac{1}{r_2^2} \]  

When \( \cos(\theta_1-\theta_2) \geq 0 \), from (5) we have

\[ r_1^2 + r_2^2 \leq 1 \]  

From (19), we get \( r_1 < 1 \), so that

\[ g_r^{(2)}(0) = \frac{1}{r_1^2} > 1 \]  

(18) shows that the bunching effect exists.

When \( \cos(\theta_1-\theta_2) < 0 \), we have \( r_1^2 + r_2^2 > 1 \), so that \( r_1^2 \) may be more than 1 and we have

\[ g_r^{(2)}(0) = \frac{1}{r_1^2} < 1 \]  

(22) Shows that the anti-bunching effect exist.

3. Conclusion

The results of this paper show that the squeezing effect, the bunching effect and the anti-bunching effect of q-deformed superposition light field state may exist and can be controlled by q-parameter.

Reference
