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 $|o>_q$ and q—Glauber coherent state $|z>_q$ are studied, the controllable q—parameter of the squeezing effect, the bunching effect and the auti—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 Sanyu[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 coutrolled by q—parameter.

We studied the squeezing effect of q—deformed superpostion light field which imvolving q—deformation vaccuum state $|o>_q$ and q — Glauber Coherent state $|z>_q$. The results showed that the squeczing 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 superpositon Light field state is

$$|\psi>_q = \alpha|o>_q + \beta|z>_q \tag{1}$$

where

$$|z>_q = e_q^{-\frac{1}{2}|z|^2}\sum_{n=0}^{\infty}\frac{Z^n}{\sqrt{[N]!}}|n>_q \tag{2}$$

$$Z = Re^{i\varphi}, \alpha = r_1e^{i\theta_1}, \beta = r_2e^{i\theta_2} \tag{3}$$

$$[X] = \frac{q^{\frac{x}{2}} - q^{-\frac{x}{2}}}{q^{\frac{1}{2}} - q^{-\frac{1}{2}}}(q \neq 1) \quad e_q^x = \sum_{n=0}^{\infty}\frac{x^n}{[N]!}, [X]! = [X].[X-1]\cdots[1] \tag{4}$$

The normalization condtion is

$$r_1^2 + r_2^2 + 2r_1r_2e_q^{-\frac{1}{2}|z|^2}\cos(\theta_1 - \theta_2) = 1 \quad (5)$$

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

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

$$Y_1 = \frac{1}{2}(a_q^+ + a_q), Y_2 = \frac{1}{2i}(a_q^+ - a_q) \quad (6)$$

where a_q is q-annihilation operator and a_q^+ is q-creaton operator. Becacsse of $[Y_1, Y_2] = \frac{i}{2}[a_q, a_q^+]$, so we have the uncertainty relation.

$$\underset{q}{<}(\Delta Y_1)^2\underset{q}{>}\underset{q}{<}(\Delta Y_2)^2\underset{q}{>} \geqslant \frac{1}{4}|<[Y_1, Y_2]>|^2 \quad (7)$$

If the squeezing exists, then we have

$$Fi = \underset{q}{<}(\Delta Y_i)^2\underset{q}{>} - \frac{1}{4} < 0 \ (i = 1,2) \quad (8)$$

For q-deformed superposition light field state, we have

$$\underset{q}{<}\psi|a_q a_q^+|\psi\underset{q}{>} = (\alpha^* \underset{q}{<}0| + \beta^* \underset{q}{<}Z|)a_q a_q^+(\alpha|0\underset{q}{>} + \beta|Z\underset{q}{>}$$

$$= |\alpha|^2 + \beta^*\alpha e_q^{-\frac{1}{2}|Z|^2} + \alpha^*\beta e_q^{-\frac{1}{2}|Z|^2} + |\beta|^2 e_q^{-|Z|^2}\sum_{n=0}^{\infty}\frac{|Z|^{2n}}{[n]!}[n+1] \quad (9)$$

$$\underset{q}{<}\psi|a_q^+ a_q|\psi\underset{q}{>} = (\alpha^* \underset{q}{<}0| + \beta^* \underset{q}{<}Z|)a_q^+ a_q(\alpha|0\underset{q}{>} + \beta|Z\underset{q}{>})$$

$$= |\beta|^2|Z|^2 \quad (10)$$

$$\underset{q}{<}\psi|a_q|\psi\underset{q}{>} = (\alpha^* \underset{q}{<}0| + \beta^* \underset{q}{<}Z|)a_q^+(\alpha|0\underset{q}{>} + \beta|Z\underset{q}{>})$$

$$= Z\alpha^*\beta e_q^{-\frac{1}{2}|Z|^2} + |\beta|^2 Z \quad (11)$$

$$\underset{q}{<}\psi|a_q^+|\psi\underset{q}{>} = (\alpha^* \underset{q}{<}0| + \beta^* \underset{q}{<}Z|)a_q^+(\alpha|0\underset{q}{>} + \beta|Z\underset{q}{>})$$

$$= \beta^*\alpha Z^* e_q^{-\frac{1}{2}|Z|^2} + |\beta|^2 Z^* \quad (12)$$

$$\underset{q}{<}\psi|a_q^{+2}|\psi\underset{q}{>} = (\alpha^* \underset{q}{<}0| + \beta^* \underset{q}{<}Z|)a_q^{+2}(\alpha|0\underset{q}{>} + \beta|Z\underset{q}{>})$$

$$= \beta^*\alpha Z^{*2}e^{-\frac{1}{2}|Z|^2} + |\beta|^2 Z^{*2} \quad (13)$$

$$\underset{q}{<}\psi|a_q^2|\psi\underset{q}{>} = (\alpha^* \underset{q}{<}0| + \beta^* \underset{q}{<}Z|)a_q^2(\alpha|0\underset{q}{>} + \beta|Z\underset{q}{>}$$

$$= \beta\alpha^* Z^2 e_q^{-\frac{1}{2}|Z|^2} + |\beta|^2 Z^2 \quad (14)$$

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

$$F_1 = \frac{1}{4}\{<a_q^{+2}> + <a_q^2> + <a_q a_q^+> + <a_q^+ a_q> - (<a_q^+> + <a_q>)^2\} - \frac{1}{4}$$

$$= \frac{1}{4}\Big[e_q^{-\frac{1}{2}R^2}r_1r_2k^2 2\cos(\theta_2 + 2\varphi - \theta_1) + r_2^2R^2 \cdot 2\cos 2\varphi + e_q^{-\frac{1}{2}R^2}r_1r_2\, 2\cos(\theta_2 - \theta_1)$$

$$+ r_2q^{-R^2}\sum_{n=0}^{\infty}\frac{R^{2n}}{[n]!}[n+1] + r_2^2R^2 + r_1^2 - (Rr_1r_2e_q^{-\frac{1}{2}R^2}\, 2\cos(\theta_2 + \varphi - \theta_1) + Rr_2^2\, 2\cos\varphi)^2 - 1\Big] \quad (15)$$

$$F_2 = \frac{1}{4}[-<a_q^{+2}> - <a_q^2> + <a_q a_q^+> + <a_q^* a_q> + (<a_q^+> - <a_q>)^2] - \frac{1}{4}$$

$$= \frac{1}{4}\Big[-e_q^{-\frac{1}{2}R^2}r_1r_2R^2 2\cos(\theta_2 - 2\varphi - \theta_1) - r_2^2R^2 2\cos 2\varphi + e_q^{-\frac{1}{2}R^2}r_1r_2\, 2\cos(\theta_1 - \theta_2)$$

$$+ r_2^2e_q^{-R^2}\sum_{n=0}^{\infty}\frac{R^{2n}}{[n]!}[n+1] + r_2^2R^2 + r_1^2 + (Rr_1r_2e_q^{-\frac{1}{2}R^2}\sin(\theta_2 + \varphi - \theta_1) - Rr_2^2\, 2\sin\varphi)^2 - 1\Big] \quad (16)$$

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

2. 2 The bunching effect, the anti—bunching effect of q—deformed superposition light field state

For q—defrmed superposition light field state, we have

$$<\psi_q|a_q^{+2}a_q^2|\psi_q> = |\beta|^2|Z|^4 \tag{17}$$

$$g_q^{(2)}(0) = \frac{<\psi_q|a_q^{+2}a_q^2|\psi_q>}{(<\psi_q|a_q^+a_q|\psi_q>)^2} = \frac{|\beta|^2|Z|^4}{|\beta|^4|Z|^4} = \frac{1}{|\beta|^2} = \frac{1}{r_2^2} \tag{18}$$

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

$$r_1^2 + r_2^2 \leqslant 1 \tag{19}$$

From (19), we get $r^2<1$, so that

$$g_q^{(2)}(0) = \frac{1}{r^2} > 1 \tag{20}$$

(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_2^2 may be more than 1 and we have

$$g_q^2(0) = \frac{1}{r^2} < 1 \tag{22}$$

(22)Shows that the anti—bunching effeet exist.

3. Conclusion

The results of this paper shows 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—parmeter.

Reference

[1] Hao Sanyu, ACTA PHYSICA SINICA, 42, 1057 (1993)

[2] Zhu Chongxu etal, ACTA PHYSICA SINICA, 43,1262(1994).