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 \( |\psi\rangle \) and q—Glauber coherent state \( |z\rangle \) 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 \(|n\rangle_q\) was obtained too. From this q—Glauber coherent state \(|n\rangle_q\) 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 controlled by q—parameter.

We studied the squeezing effect of q—deformed superposition light field which involving q—deformation vacuum state \(|\psi\rangle\) and q—Glauber Coherent state \(|z\rangle\). 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

\[ |\psi\rangle = a|\psi\rangle + \beta|z\rangle \tag{1} \]

where

\[ |z\rangle = c_z^{\frac{1}{2} |i\rangle S^z - q^\frac{1}{2} |0\rangle_{\{N\}} \tag{2} \]

\[ Z = Re^{\alpha}, \alpha = r e^{\epsilon i}, \beta = r e^{\epsilon i} \tag{3} \]

\[ [X] = q^\frac{i}{2} - q^{-\frac{i}{2}} (q \neq 1), \quad \epsilon_1 = \sum_{r=1}^{\infty} \frac{z^r}{r!}, [X]! = [X], [X-1] \ldots [1] \tag{4} \]

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

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

\[ Y_1 = \frac{1}{\sqrt{2}} (a_q^+ + a_q), \quad Y_2 = \frac{1}{\sqrt{2}} (a_q^+ - a_q) \]

where \( a_q \) is q-annihilation operator and \( a_q^+ \) is q-creation operator. Because of \([Y_1, Y_2] = \frac{i}{\sqrt{2}} [a_q, a_q^+]\), so we have the uncertainty relation.

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

If the squeezing exists, then we have

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

For q-deformed superposition light field state, we have

\[ \langle \psi | a_q a_q^+ | \psi \rangle = (a^* < 0 | + \beta^* < Z |) a_q a_q^+ (| 0 \rangle + \beta | Z \rangle) \]

\[ = |a|^2 + \beta^* e^{\frac{i}{2}z^2} + |\beta|^2 |Z|^2 \]

\[ \langle \psi | a_q^2 | \psi \rangle = (a^* < 0 | + \beta^* < Z |) a_q^2 (| 0 \rangle + \beta | Z \rangle) \]

\[ = \beta^* a Z e^{\frac{i}{2}z^2} + |\beta|^2 |Z|^2 \]

\[ \langle \psi | a_q^2 | \psi \rangle = (a^* < 0 | + \beta^* < Z |) a_q^2 (| 0 \rangle + \beta | Z \rangle) \]

\[ = \beta^* a Z e^{\frac{i}{2}z^2} + |\beta|^2 |Z|^2 \]

From (8) – (14), we can have

\[ F_1 = \frac{1}{4} \left( \langle a_q^2 \rangle - \langle a_q^2 \rangle > + \langle a_q^2 \rangle + \langle a_q^2 \rangle + \langle a_q^2 \rangle + \langle a_q^2 \rangle \right) - \frac{1}{4} \]

\[ = \frac{1}{4} \left[ \sum_{n=1}^{\infty} \left[ a^2 + \frac{1}{2} \right] \right] + \sum_{n=1}^{\infty} \left[ a^2 + \frac{1}{2} \right] - \frac{1}{4} \]

\[ F_2 = \frac{1}{4} \left( -\langle a_q^2 \rangle - \langle a_q^2 \rangle + \langle a_q^2 \rangle + \langle a_q^2 \rangle + \langle a_q^2 \rangle - \langle a_q^2 \rangle \right) - \frac{1}{4} \]

\[ = \frac{1}{4} \left[ -\sum_{n=1}^{\infty} \left[ a^2 + \frac{1}{2} \right] \right] + \sum_{n=1}^{\infty} \left[ a^2 + \frac{1}{2} \right] - \frac{1}{4} \]

It is clear \( F_1 \) and \( F_2 \) are periodic function of \( q \). Numerical value 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 \( q \).
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

\[ \langle \psi | a_r^+ a_r^2 | \psi \rangle = |\beta|^2 |Z|^4 \]  \hspace{1cm} (17)

\[ g_r^{(2)}(0) = \frac{\langle \psi | a_r^+ a_r^2 | \psi \rangle}{\langle \psi | a_r^+ a_r | \psi \rangle^2} = \frac{|\beta|^2 |Z|^4}{|\beta|^4 |Z|^4} = \frac{1}{r^2} = \frac{1}{r_f^2} \]  \hspace{1cm} (18)

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

\[ r_f^2 + r_z^2 \leq 1 \]  \hspace{1cm} (19)

From (19), we get \( r_f^2 \leq 1 \), so that

\[ g_r^{(2)}(0) = \frac{1}{r_f^2} > 1 \]  \hspace{1cm} (20)

(18) shows that the bunching effect exists.

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

\[ g_r^{(2)}(0) = \frac{1}{r_f^2} < 1 \]  \hspace{1cm} (22)

(22) Shows that the anti—bunching effect 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—parameter.

Reference
