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Correlation between classical Fisher information and quantum squeezing properties of Gaussian pure states

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Abstract. The Fisher information of Gaussian pure states is studied in this work. Based on the definition of joint non-classical properties, we calculate the non-classical properties of Gaussian pure states. The results show that the Fisher information and Fisher length are efficacious tools to study the non-classical properties of quantum states. And the non-classical properties of states can be used to calculate the quantum properties quantificationally. Making use of Fisher information, one can obtain the correlation between the Fisher information and quantum squeezing properties of Gaussian pure states. Especially, it is significative that one can quantificationally describes the fluctuation of quantum states by an alternative new method.

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Key words: Gaussian pure states, Fisher information, Fisher length, joint non-classical properties

1 Introduction

Gaussian pure states is an important quantum states in quantum optics domains, it can describe the coherent output of laser and the squeezing optics field of parametric process. In mathematical field Gaussian pure states represent a category distribution namely Gaussian distribution [1]. The Hamiltonian operator of Gaussian pure states is a simple quantum function. So some pursuer have been interested in Gaussian pure states over the past few years and obtained some significative results. For example, Walls and Milburn gave some results of standard forms and entanglement engineering of multimode Gaussian states [2] and Xia *et al.* studied the higher-order squeezing and information entropy for Gaussian pure states [3].

Fisher information was originally introduced by Fisher, as a measure of ”intrinsic accuracy” in statistical estimation theory. It provides in particular a bound on the degree to

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which members of a family of probability distributions can be distinguished [4]. Quantum generalizations of Fisher information may be also provide corresponding bounds on the degree to which members of a family of quantum states can be distinguisher by measurement [5–9]. These results show that Fisher information closely correlates to the quantum properties of states. It is well-known that further studies on the quantum states and properties of quantum states are very important to the creation of quantum optics fields and entangled states [10, 11], which are the basic of quantum communication and quantum computation [12].

In this work, based on the definitions of Fisher information and Fisher length, we study the Fisher information and joint non-classical properties of Gaussian pure states. We calculate the Fisher information and Fisher length of Gaussian pure states. The results show that there has been a close relationship between classical Fisher information and quantum squeezing properties of Gaussian pure states. Thus we can investigate the quantum properties of Gaussian pure states in a fire-new way.

2 Function of Gaussian pure states

In coordinate representation single mode Gaussian pure states is given by [1,3]

$$\psi_g(x)=\langle x|\mu_g\rangle=N_g\exp\left(\frac{1}{2}i\sigma_x+\frac{1}{2}ix_0p_0+ip_0x\right)\exp\left[-\frac{r}{2}(x-x_0)^2\right], \tag{1}$$

where x_0 and p_0 are given by the function

$$p_0=\bar{p}=\langle p\rangle=\int_{-\infty}^{+\infty}dx\langle\mu_g|x\rangle\left(-i\frac{\partial}{\partial x}\right)\langle x|\mu_g\rangle, \tag{2}$$

$$x_0=\bar{x}=\langle x\rangle=\int_{-\infty}^{+\infty}dx|\langle x|\mu_g\rangle|^2x, \tag{3}$$

where we assume $\hbar=1$ and $\omega=1$ for the convenience of the study. σ_x denotes the immeasurable phase angle, $r=r_1+ir_2$ is a complex number, in which r exerts a determining influence on a specific Gaussian pure states and $\mathrm{Re}(r)=r_1>0$. The normalized constant N_g is defined as

$$N_g=(\pi/r_1)^{-1/4}. \tag{4}$$

In momentum representation Gaussian pure states is given by

$$\psi_g(p)=\langle p|\mu_g\rangle=n_g\exp\left(-\frac{1}{2}i\sigma_p+\frac{1}{2}ix_0p_0-ipx_0\right)\exp\left[-\frac{r}{2}(p-p_0)^2\right], \tag{5}$$

where the normalized constant n_g is given by

$$n_g=(\pi|r|^2/r_1)^{-1/4}. \tag{6}$$