Optical correlations play a major role in quantum information and quantum technologies. An optical state can be investigated using an interferometric setup, that consists of a two-modes state mixing in a beam splitter, whose two outputs are revealed by photodetectors. These measurements, in general, give rise to a nonzero intensity correlation function and quantum correlations.
It is known that if we mix two equals thermal states in a balanced beam splitter, the resulting intensity correlation of the two outputs vanishes. This effect is due to the particular dependence of the energy variance on the energy mean value. The thermal states class is classical and arises whenever we need to describe the optical properties of a radiation field at thermal equilibrium, e.g. black body radiation, but it can be generated also in quantum optics laboratories by suitably manipulating the optical fields, for instance, by means of rotating ground glass (Arecchi's disks).

In this thesis we study the quantum properties of an optical state, expressed by the following diagonal density operator: $\hat{\varrho}_m = p_0 |0\rangle \langle 0| + p_1 |1\rangle \langle 1| + p_2 |2\rangle \langle 2|$ where $|n\rangle$ is a Fock state.
We want this state to have the same first two moments i.e. mean and variance, of a thermal state, in order to have a vanishing intensity correlation, once we mix two $\hat{\varrho}_m$ in a balanced beam splitter.

With these assumptions, we can investigate the quantum or classical correlations that might arise after a beam splitter interaction. Our purpose is to study the nonclassicality and the nonlocality of this state quantitatively.
The nonclassicality of a quantum light state is related to its impossibility to be described by the classical Maxwell equations and can be quantified by the so-called nonclassical depth τ. It turns out that this parameter is maximized, namely $\tau = 1$, by Fock states, and minimized, $\tau = 0$, by coherent states, making the Fock states $|n\rangle$ the most nonclassical states among all the optical states. This parameter can thus be related to the number of thermal photons that have to be added to a quantum state in order to erase all its quantum features. In order to compute this parameter we introduced a class of functions, the quasi-probability function and the Wigner function, that allow us to put some sufficient conditions about the nonclassicality of our state. In particular, we want to evaluate whenever the quasi-probability function is always positive-defined and can be considered as a classical probability distribution function. It turns out that the nonclassical depth of our state is a linear positive function of the energy. Thus, we can state that $\hat{\varrho}_m$ is certainly nonclassical as its nonclassical depth is higher than zero.

Secondly, we have to evaluate the nonlocality of $\hat{\varrho}_m$. This quantum feature is related to the possibility of nonlocal interactions by two causal disconnected subsystems, in our case, after the interaction in the beam splitter. In this case, we follow the approach based on the Bell inequalities, in particular the CHSH inequality. It states that, if it holds $2 < |\mathcal{B}| < 2\sqrt{2}$, with $\mathcal{B}$ the Bell parameter, then we are dealing with a nonlocal system. This is, therefore, a sufficient condition. In our case, $\hat{\varrho}_m$ is sent in a beam splitter and made mixing firstly with the vacuum state $|0\rangle \langle 0|$, and secondly with another copy of itself. We computed that in every case it is $|\mathcal{B}| < 2$. The output state doesn't show any violation of the considered Bell inequality, that is just a sufficient but not necessary condition to have nonlocality, and, thus, other approaches are needed to investigate the possible nonlocal feature of the state.

This work puts the basis for further studies, as we deal with a nonclassical state. In particular, could be interesting to analyze Bell inequalities different from the CHSH one, or make consideration at entropy or information level. This state might display interesting quantum features that could be used in quantum cryptography or quantum communication.