Preface

The thesis is dedicated to the study of oscillatory phase of inflaton by representing it in nonclassical state formalisms of quantum optics. The thesis deals with the role of nonclassical and thermal effects of inflaton in semiclassical theory of gravity in the post inflationary era of the universe.

The standard cosmology is spectacularly successful but the model leaves many features of the universe unexplained. The most important of these are horizon problem, singularity problem, flatness problem, homogeneity problem, structure formation problem, monopole problem and so on. All these problems are very difficult and defy solutions within the standard cosmology theory. Most of these problems can be addressed or considerably relaxed in the inflationary scenario. According to which the universe in the past expanded almost exponentially with time, while its energy density was dominated by the effective potential energy density of a homogeneous scalar field, called the inflaton. At the end of inflation the inflaton field started quasi-periodic motion with slowly decreasing amplitude. Right after the inflationary period the universe was devoid of particles, that is, cold. Quasi-periodic evolution of the inflaton field led to creation of particles of various kinds, after thermalization of which due to collisions and decays, the universe became hot again. From then on, it can be described by the usual hot big bang theory. Therefore the oscillatory phase of the inflaton and its related issues are important to understand particle creation and further evolution of the universe.

Most of the inflationary scenario and related issues can be described with
a scalar field in the classical Friedmann equations, assuming its validity even at the very early stage of the universe. However, it is believed that quantum effects of matter fields and quantum fluctuations played significant role in this regime, though quantum gravity effects are considered to be negligible. Therefore, the proper description of a cosmological model can be studied in terms of the semiclassical Friedmann equations in which quantized matter field is taken as source and the corresponding background metric as classical. Recently, the study of inflation and its related issues in the semiclassical theory of gravity has received much attention.

In the present work we use the coherent and squeezed state formalisms of quantum optics to study the inflaton in the oscillatory phase, in the semiclassical theory of gravity. We study particle production, density fluctuations and validity of the semiclassical theory of gravity in the flat Friedmann universe. Since we use the representation of the inflaton in the coherent and squeezed states, it would be useful to examine classical or nonclassical nature of the field, in the cosmological context. In quantum optics context such study is carried out by using a parameter known as the Mandel’s $Q$ parameter and is studied in the cosmological context with the associated cosmological parameters.

The aim of the present study is to consider the flat Friedmann model of the universe in the semiclassical theory of gravity. However, the solutions of the Friedmann model imply an open and a closed Friedmann models also. Therefore it is interesting to see how the semiclassical gravity and its related phenomenon play role in determining dynamics of the open and closed Friedmann models. Thus the general goal of the present work is to study a massive minimal nonclassical scalar field in the flat, open and closed Friedmann universe by representing it in terms of the coherent and squeezed state formalisms of quantum optics as well as in their thermal counterparts.