I. INTRODUCTION

In cavity quantum electrodynamics, an interesting regime, called the regime of strong coupling, occurs when the maximal atom-field dipole coupling strength exceeds the cavity field decay rate and the atomic spontaneous emission rate [1]. In this regime, excitations can be exchanged coherently between the atom and the field several times before the incoherent decay process occurs, the properties of the field can be significantly modified by the presence of even a single atom, and the presence of a single photon in the field can saturate the response of the atom. The effects of single atoms on the cavity field in real time [2, 3] have been observed [4–6]. It has been reported that the presence of an atom in the cavity, which is tuned to the atomic transition and resonantly driven by a laser field, can lead to a dramatic drop in the transmitted intensity [4]. It has been demonstrated [7, 8] that the spatial variation of the cavity mode can lead to a confining potential sufficient to trap an atom within the cavity mode even for a single quantum of excitation [9–11]. Cooling [12] of single atoms with single photons in a high-Q cavity has also been investigated.

Recently, it has been proposed to combine the cavity technique with the nanofiber technique to obtain a hybrid system, where the interaction is enhanced by the transverse confinement of the field in the fiber cross-section plane as well as the longitudinal confinement of the field between the mirrors. It has been shown that the presence of a fiber-Bragg-grating (FBG) cavity with a large length (on the order of 10 cm) and a moderate finesse (about 30) can significantly enhance the group delay of a guided probe field [13] and substantially enhance the channeling of emission from an atom into a nanostructure [14]. There has been a large body of work involving fiber Bragg gratings over the past two decades [15–20]. With careful control of the grating writing process and appropriate choice of glass material, a FBG resonator can have a finesse of well over 1000 and a linewidth of a few MHz [20]. It is worth mentioning that several methods for trapping and guiding neutral atoms outside a fiber have been proposed and studied [21–27]. A trapping method based on the use of two (red- and blue-detuned) light beams has been studied for large-radius fibers [21] and nanofibers [23] and has recently been experimentally realized [27].

In this paper, we study the interaction of an atom with a quantum guided field in a weakly driven FBG cavity. We show that, due to the confinement of the guided cavity field in the fiber cross-section plane and in the space between the FBG mirrors, the presence