Title:	Quantum theory of statistical radiation pressure in free space
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Abstract:	Light is known to exert radiation pressure on any surface it is incident upon, via the transfer of momentum from the light to the surface. In general, this force is assumed to be pushing or repulsive in nature. In this paper, we present a quantum treatment of radiation pressure. We show that the interaction of an atom with light can lead to both repulsive and attractive forces due to absorption and emission of photons, respectively. An atom prepared in the excited state initially will experience a pulling force when interacting with light. On the other hand, if the atom is prepared in the ground state then the force will be repulsive, while having the same magnitude as in the earlier case. Therefore, for an ensemble of atoms, the direction of the net force will be decided by the excited and ground state populations. In the semi-classical treatment of light-matter interaction the absorption and emission processes have the same probability, therefore the magnitudes of the force in the two processes turn out to be the same. We obtain the effective emission profile for an excited atom interacting with quantum electromagnetic field, and show that in the quantum treatment, despite these probabilities being different, the magnitudes of the statistical force remain the same. This can be explained by noting that the extra contribution in the emission process is due to the interaction of the atom with the vacuum modes of electromagnetic field, results in symmetric emission profile, contributing to a net zero force on the atoms in an ensemble. We further identify the set of states of electromagnetic field which give rise to non-zero momentum transfer to the atom.
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