# Dipole trapping around nanostructured waveguides

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This will be our cool abstract. In fact, it will probably be the coolest abstract ever. Humanity will be proud. Crowds will carry us to the pantheon of the abstract writers. We will be crowned kings. NonG and Free space will obey our every orders and we shall reign forever. FOREVER.

## I. INTRODUCTION

Confinement(Localization) and precise positioning of quantum emitters within the mode the EM field is crucial for creating efficient light matter interface for quantum optics and quantum network applications[1]. In atom based quantum technology, this is usually implemented by optical dipole trapping[2]. Optically trapped atoms have been used for creating efficient light-matter interface in Free space[3, 4] or inside a cavity[5, 6].

In the recent years, atoms trapped near nanophotonic structures have emerged as a leading platform for efficient light matter interface [7]. Optical nanofiber[8–11], Photonic crystal waveguide[12, 13] and Toroidal micro-cavity[14] to name a few. These type of platforms relies on evanescent field interfacing, which comes with two main added advantages. (i) Superior atom-light interaction strength due to strong confinement of the electromagnetic field. (ii) Interaction with a large sample, not limited by the Rayleigh range, enhancing the collective cooperative effect. To achieve the desired coupling strength in such platform, its crucial to trap the atoms within $1/e^2$ decay of the evanescent field. There are many proposals for trapping atoms atoms in evanescent field near nanophotonic structures. However, only a few have been experimentally implemented. In this article, we briefly review the schemes for optical trapping of atoms near the nanophotonic structures and then present a Python platform that we have developed for simulating optical dipole trap for alkali atoms near nanophotonic structures.

## II. REVIEW

### A. Nanofiber

Optical nanofiber is probably the most prominent platform for atom-nanophotonics interface so far. Relatively simple fabrication technique of Subwavelength-diameter, low-loss silica nanofiber[15] and its non-meddling intigability with cold atomic system, makes it a popular choice. Early work involved optical nanofiber embedded in an ensemble of magneto-optically trapped atoms[16, 17]. The first proposal on trapping atoms using the evanescent field of an optical nanofiber was by balancing the attractive gradient force of a red-detuned evanescent-wave field with the centrifugal force when the fiber diameter is about two times smaller than the wavelength of the trapping light[18]. Later it was proposed that the attractive force can be counter-balanced by a blue-detuned evanescent-wave field propagating in the same nanofiber, giving birth to the popular two-color evanescent field trap[19].

### B. Photonic crystal structure

Discuss work of Kimble and Hakuta here.

### C. Microtoroid and other possible structures

## III. THEORETICAL FRAMEWORK

### A. Subsection A

### B. Subsection A

### C. Subsection A

## IV. CONCLUSION

## ACKNOWLEDGMENTS

## Appendix A: Appendix A

[1] H. J. Kimble, Nature **453**, 1023 (2008), arXiv:0806.4195.
[2] R. Grimm and M. a. P. H. I. a. S. Weidemuller, *Advances in Atomic, Molecular and Optical Physics*, Vol. 42 (2000) pp. 95–170.
[3] M. K. Tey, Z. Chen, S. A. Aljunid, B. Chng, F. Huber, G. Maslennikov, and C. Kurtsiefer, Nature Physics **4**, 924 (2008).
[4] B. Darquié, M. P. A. Jones, J. Dingjan, J. Beugnon, S. Bergamini, Y. Sortais, G. Messin, A. Browaeys, and P. Grangier, Science **309**, 454 (2005), https://science.sciencemag.org/content/309/5733/454.full.pdf.
[5] J. Ye, D. W. Vernooy, and H. J. Kimble, Phys. Rev. Lett. **83**, 4987 (1999).
[6] H. Walther, B. T. H. Varcoe, B.-G. Englert, and T. Becker, Reports on Progress in Physics **69**, 1325 (2006).
[7] D. E. Chang, J. S. Douglas, A. González-Tudela, C.-L. Hung, and H. J. Kimble, Rev. Mod. Phys. **90**, 31002 (2018).
[8] E. Vetsch, D. Reitz, G. Sagué, R. Schmidt, S. T. Dawkins, and A. Rauschenbeutel, Phys. Rev. Lett. **104**, 203603 (2010).
[9] N. V. Corzo, B. Gouraud, A. Chandra, A. Goban, A. S. Sheremet, D. V. Kupriyanov, and J. Laurat, Phys. Rev. Lett. **117**, 133603 (2016).
[10] N. V. Corzo, J. Raskop, A. Chandra, A. S. Sheremet, B. Gouraud, and J. Laurat, Nature **566**, 359 (2019).
[11] T. Nieddu, V. Gokhroo, and S. N. Chormaic, Journal of Optics (United Kingdom) **18**, 053001 (2016).
[12] A. Goban, C. L. Hung, S. P. Yu, J. D. Hood, J. A. Muniz, J. H. Lee, M. J. Martin, A. C. McClung, K. S. Choi, D. E. Chang, O. Painter, and H. J. Kimble, Nature Communications **5**, 3808 (2014).
[13] K. P. Nayak, J. Wang, and J. Keloth, Physical Review Letters **123**, 213602 (2019), arXiv:1908.03319.
[14] H. Mabuchi and H. J. Kimble, Proceedings of the International Quantum Electronics Conference (IQEC'94) **19**, 80 (1994).
[15] L. Tong, R. R. Gattass, J. B. Ashcom, S. He, J. Lou, M. Shen, I. Maxwell, and E. Mazur, Nature **426**, 816 (2003).
[16] K. P. Nayak, P. N. Melentiev, M. Morinaga, F. L. Kien, V. I. Balykin, and K. Hakuta, Opt. Express **15**, 5431 (2007).
[17] K. P. Nayak, F. Le Kien, M. Morinaga, and K. Hakuta, Phys. Rev. A **79**, 021801 (2009).
[18] V. I. Balykin, K. Hakuta, F. Le Kien, J. Q. Liang, and M. Morinaga, Physical Review A - Atomic, Molecular, and Optical Physics **70**, 2 (2004), arXiv:0404110 [physics].
[19] F. L. Kien, V. I. Balykin, and K. Hakuta, Physical Review A - Atomic, Molecular, and Optical Physics **70**, 1 (2004), arXiv:0407107 [quant-ph].