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High-Q Photonic Device for Trapping and Detecting a Single Atom on a Chip.

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Recent progress in manufacturing high-Q dielectric microresonant structures may enable their use as photonic devices that can manipulate and/or detect single atoms on a nanometer scale. Of specific interest is the wafer-based manufacturing of resonators where good control of the physical characteristics can be achieved during fabrication and operation when integrated with other functions on the chip.

We investigate possibilities for simultaneously trapping and detecting single atoms near the surface of a substrate using the evanescent field of optical whispering gallery modes (WGMs) supported by a toroid microcavity. The advantages are the small electromagnetic mode volume and the high-Q value that can be achieved in a microdisk resonator[1].

We have calculated the evanescent fields of some optical WGMs and have found that the atom should be placed within 80 - 180 nm from the disk for efficient atom-mode coupling. Such proximity should be feasible by balancing the attractive van der Waals/Casimir forces, the repulsive blue-detuned resonator light which is used for atom detection, and red-detuned light used to create the trap[2].

We show that this "all-optical" trapping should be stable[2]. We discuss atom detection efficiencies and the feasibility for non-destructive measurements in such systems and their dependence on key parameters such as atom distance from the surface, intensity of red- and blue-detuned laser pump fields, and disk size.

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[1] M. Rosenblit, P. Horak, S. Helsby, and R. Folman, Phys. Rev., A70, 053808 (2004).
[2] M. Rosenblit, Y. Japha, P. Horak, and R. Folman, Phys. Rev. A73, in print (2006).