Quantum Physics

Trapped Ion Imaging with a High Numerical Aperture Spherical Mirror

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Efficient collection and analysis of trapped ion qubit fluorescence is essential for robust qubit state detection in trapped ion quantum computing schemes. We discuss simple techniques of improving photon collection efficiency using high numerical aperture (N.A.) reflective optics. To test these techniques we placed a spherical mirror with an effective N.A. of about 0.9 inside a vacuum chamber in the vicinity of a linear Paul trap. We demonstrate stable and reliable trapping of single barium ions, in excellent agreement with our simulations of the electric field in this setup. While a large N.A. spherical mirror introduces significant spherical aberration, the ion image quality can be greatly improved by a specially designed aspheric corrector lens located outside the vacuum system. Our simulations show that the spherical mirror/corrector design is an easy and cost-effective way to achieve high photon collection rates when compared to a more sophisticated parabolic mirror setup.

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