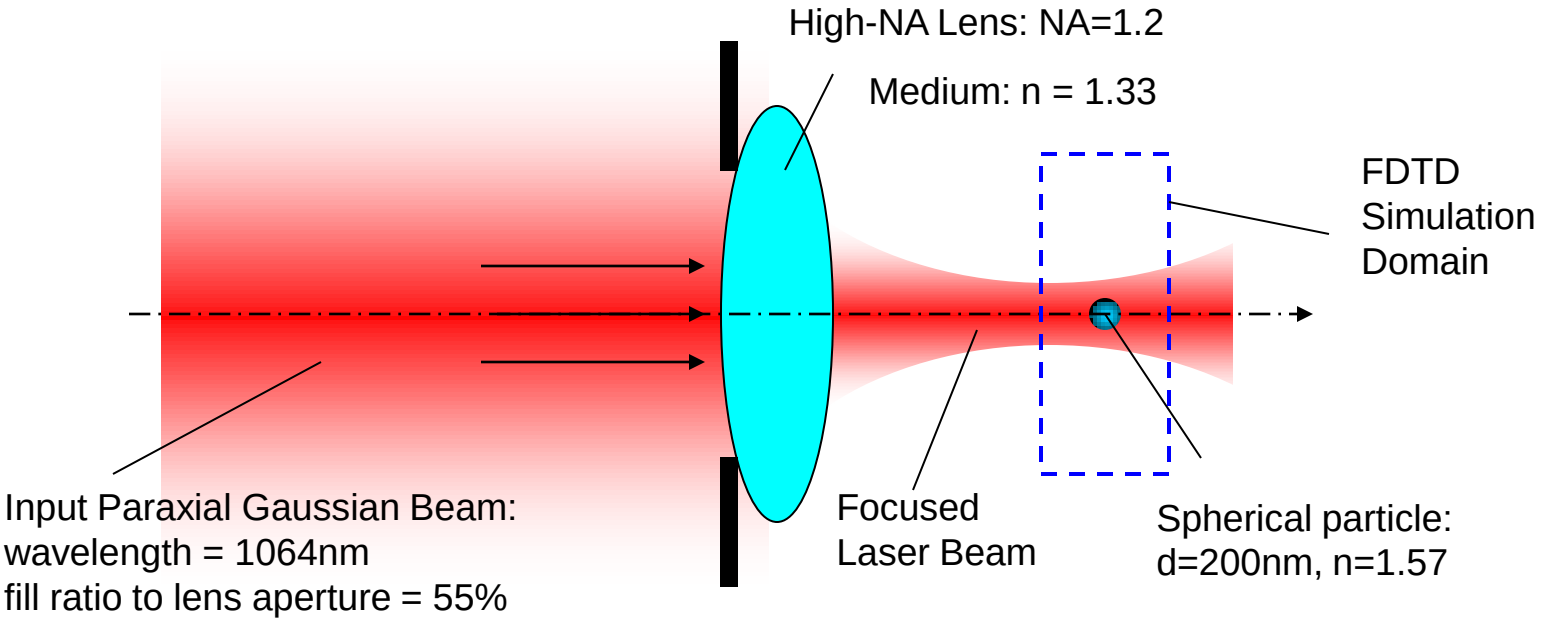
EM EXPLORER At The Edge

Optical Tweezer Simulation

Overview

- This work simulates the optical trapping force on a spherical particle in a focused laser beam produced by a high numerical aperture (NA) lens using EM Explorer.
- The following simulation parameters are based on the work of Rohrbach and Stelzer [1]



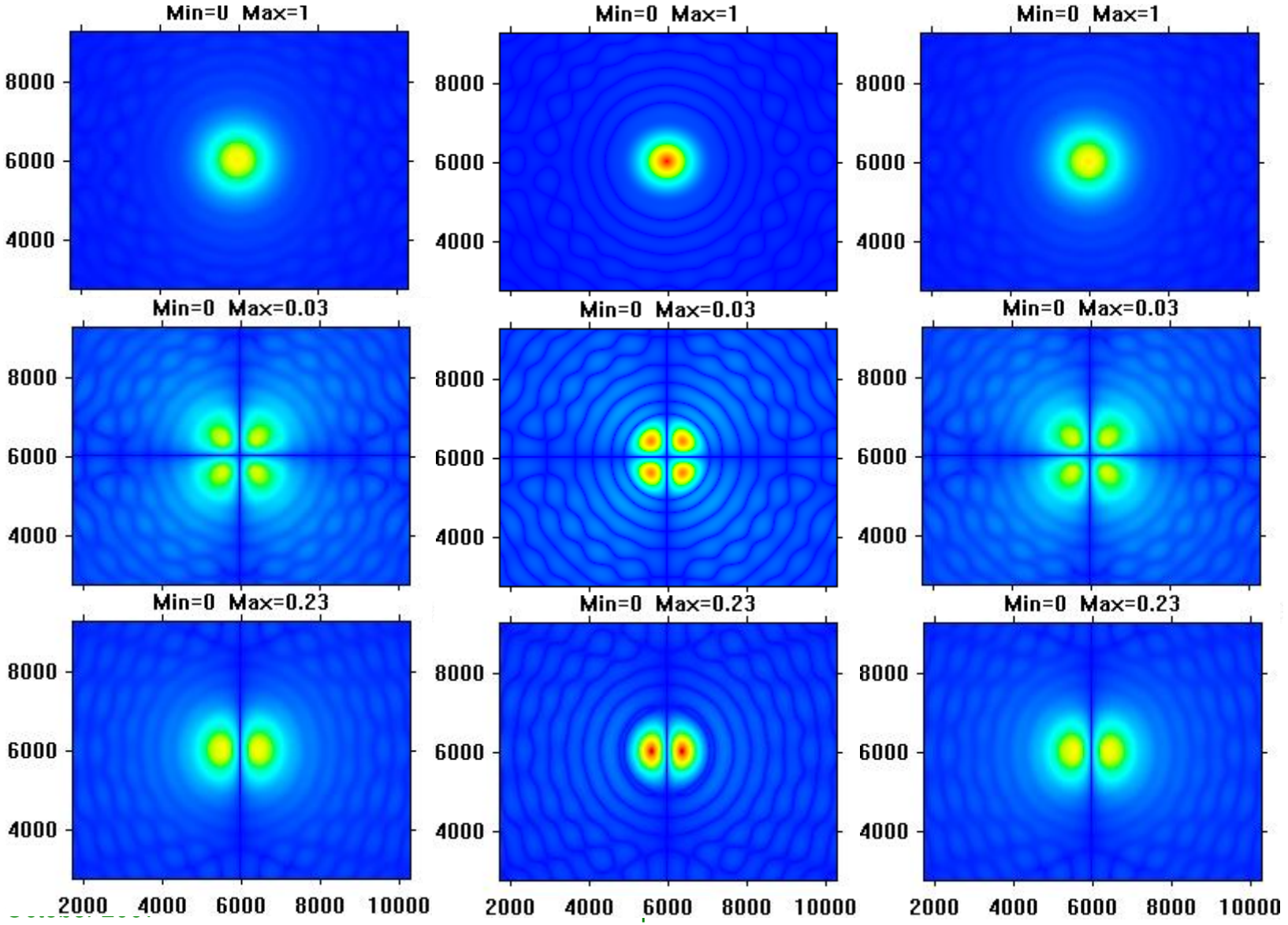
Focused Laser Beam Field

- The focused electromagnetic (EM) field produced by the high-NA lens is simulated internally using the focusing lens simulation engine of EM Explorer (version 4.6).
  - The calculated field is used as the incident field to excite the FDTD simulation domain via the "focused_beam" command (version 4.6).
  - The FDTD simulation domain encloses the particle of interest.

- The focusing lens simulation engine can also be used as a standalone module in EM Explorer Pro (via "focusing_lens" command, version 4.6)
  - Independent of the FDTD simulation engine
  - Used in conjunction with other simulation engines in EM Explorer Pro (e.g., near-field to far-field simulation engine, film stack simulation engine, etc…) to propagate and transform the field.

Focused Field Amplitude in Free space

Input beam polarization = X



800nm upstream focal plane

Focal plane

800nm downstream focal plane

Particle Trapping Force

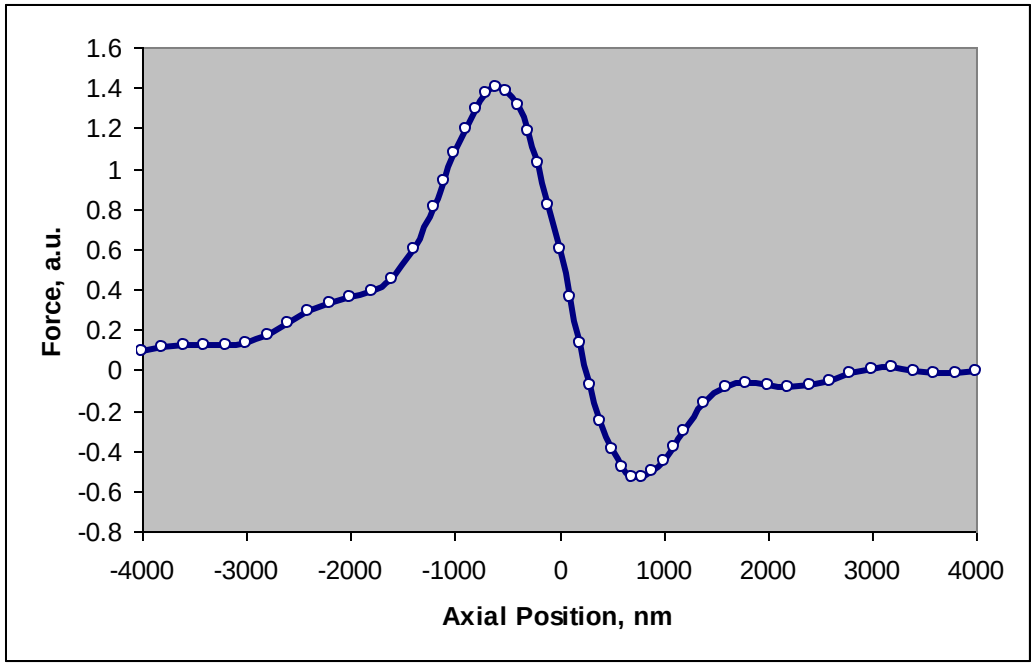
- The trapping force on a particle in a focused field can be calculated as follows [1-3].

$$\vec{F} = \kappa \int_V \nabla \left|\vec{E}\right|^2 dv = \kappa \int_S \left|\vec{E}\right|^2 d\vec{s}$$

where the integration is over the particle volume or surface. ***E*** is the total electric field with the presence of the particle, calculated by the FDTD simulation engine of EM Explorer. κ is a constant.

- A simple numerical implementation of the above trapping force calculation is written as a user-defined function in TCL scripting language. It is called by the main EM Explorer script to calculate the trapping force after the FDTD simulation is done.

Calculated trapping force as a function of particle axial position relative to focal point



References

[1] A. Rohrbach and E. H. K. Stelzer, “Optical trapping of dielectric particles in arbitrary fields,” J. Opt. Soc. Am A, Vol. 18, No. 4, April 2001

[2] P. C. Chaumet, “Comment on ‘Trapping force, force constant, and potential depths for dielectric spheres in the presence of spherical aberrations,’” Applied Optics, Vol. 43, No. 9, 20 March 2004

[3] A. Rohrbach, H. Kress, and E. H. K. Stelzer, “Reply to comment on ‘Trapping force, force constant, and potential depths for dielectric spheres in the presence of spherical aberrations,’” Applied Optics, Vol. 43, No. 9, 20 March 2004