

# Computational Electromagnetics: “Plenty of Room at the Bottom”

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## Abstract

At the risk of overusing Richard Feynman’s famous quote, the paper argues that there is “plenty of room at the bottom” for computational electromagnetics. Examples include problems in Molecular Dynamics, Scanning Near-Field Optical Microscopy (SNOM), colloidal systems, and nano-photonics. In addition to traditional techniques such as FEM, the new finite-difference calculus of Flexible Local Approximation MEthods (FLAME) is used in some applications.

In the simulation of colloidal particles, the electrostatic potential is governed – at least for monovalent microions – by the Poisson-Boltzmann Equation. The new FLAME schemes approximate the potential in the vicinity of colloidal particles *algebraically*, by suitable basis functions, rather than geometrically on conforming meshes. The accuracy is substantially higher than in conventional finite-difference analysis and even in FEM in some cases. Construction of high order FLAME schemes is considered, and error analysis of the potential, field and forces is presented.

In nano-photonics, FLAME schemes are applied to optical wave propagation in photonic crystals. For cylindrical dielectric rods, local analytical approximations of the field via cylindrical harmonics are incorporated into FLAME and produce high-order schemes.

In SNOM, the key goal is to design optical tips that provide very high field enhancement at the apex and at the same time are not difficult to fabricate. Our original design presented in the paper amplifies the field by a factor of about 50, with the commensurate enhancement of the Raman signal by a factor of about six million. Full-wave analysis of the field employs FEM with edge elements.