Physics of imaging in fluorescence microscopy

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The presentation will provide a systematic introduction to the physics of fluorescence microscopy, with a specific focus on the optical imaging aspects of fluorescence microscopy. We will cover classical optical systems such as the wide-field microscope and confocal scanning microscope, along with an extensive range of advanced and super-resolution microscopy methods. The tutorial will be organized into the following topics:

1. Brief historical introduction
2. Point Spread Function and image formation
   - Fundamental property of microscopic imaging: Abbe's sine condition
   - Electromagnetic field of image formation
   - Point spread function
   - Electromagnetic field emission of an oscillating electric dipole
   - Scalar approximation of PSF
   - Optical aberrations
3. Near field effects
   - Total internal reflection fluorescence microscopy
   - Super-critical fluorescence microscopy
   - Metal-induced energy transfer imaging
4. Point scanning microscopy
   - Confocal laser scanning microscopy
   - Image scanning microscopy
   - 4pi microscopy
   - Two-photon microscopy
5. Advanced concepts
   - Structured illumination microscope
   - Image Scanning Microscopy

Literature

- Enderlein, J. (2014). *Advanced fluorescence microscopy*. Comprehensive Biomedical Physics, 4, 111-151.
- Fazel, M., Grussmayer, K. S., Ferdman, B., Radenovic, A., Shechtman, Y., Enderlein, J., & Pressé, S. (2024). Fluorescence Microscopy: a statistics-optics perspective. *Reviews of Modern Physics* **96(2)**, 025003. https://doi.org/10.1103/RevModPhys.96.025003