Syllabus

PHYS 931: Electrodynamics 2
Kansas State University
Spring 2021

Instructor: Dr. Matthew Berg
Lecture: (F2F) Tu/Th 9:30-10:45 in CW 130
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Figure 1: Mie Theory - Maxwell’s equations can be solved analytically for a uniform sphere illuminated by an electromagnetic wave. When the solution is cast as a boundary value problem, it is known as Mie theory and will be a topic of interest this semester. Mie theory enables simulations of the distribution of light within a dielectric sphere, which if the sphere is both large (compared to $\lambda$) and strongly refractive, very complicated field patterns can occur. Resonances of the internal field, known as “whispering gallery modes,” (WGM) can be excited optically in such a sphere. The two images on the left schematically show the internal electric-field pattern of a WGM around a sphere’s equator [G. Lin et al., Adv. Opt. Photonics 9, (2017)]. These field patterns can actually be visualized. The image on the right shows a fiber optic tip delivering light to a 300 $\mu$m diameter glass sphere, exciting WGMs [A. Matsko et al., NASA JPL (2008)]. The image is made by immersing the sphere in a fluorescing fluid where the evanescent component of the WGM field leaking out of the sphere provide fluorescence excitation, which is visible in this case.


Prerequisites: PHYS 633 [Electromagnetic Fields 2], PHYS 801 [Mathematical Methods of Physics], and PHYS 831 [Electrodynamics 1]

Overview: The purpose of this course is to provide you with an advanced knowledge of electrodynamics and practice with the various mathematical techniques used in this field. Because the course has Mathematical Methods as a prerequisite, I will try hard to focus more on the physical aspects rather than making this a tour de force on special functions and the like. While some new concepts will be presented, much of the general topics discussed will not be new to you. What will be new is to see how many of the assumption/simplifications that restricted the scope of problems that you could solve before, e.g., in PHYS 633, are removed here. The result will be to expand your analytical abilities in electrodynamics, which will also be highly valuable in other subjects and perhaps even in your own research pursuits.

Outline: In general, this course will focus mostly on electrodynamics, i.e., time-dependent phenomena. Overall, I intend to follow the structure of the book as we move through the material with a few ‘asides’ and supplements here-and-there. Thus, a general outline is as follows:

- Induction [Ch. 5]
- Maxwell’s equations [Ch. 6]
- Electromagnetic waves: plane waves, waveguides, basic optics [Chs. 7 & 8]
- Electromagnetic radiation [Ch. 9]
• Electromagnetic scattering [Ch. 10]

• Selected topics (time permitting) in relativistic electrodynamics [Chs. 11-16]

**Homework:** Given the complexity of this material and that there is only so much I can convey during the lectures, the way that you will really master the material is through solving problems. Thus, we will have a number of problem sets consisting of problems from the text, fragments thereof, and other relevant *ad hoc* problems. The intent is not to kill-you-dead with the book’s infamously difficult problems, but rather to gradually develop the analytical skills that are commonly needed in the subject. Indeed, the mathematical techniques alone will almost surely be seen again in other courses. I will try to keep the time demands associated with homework reasonable since I know that you have other classes and research to do. Homework will constitute 60% of your grade.

**Guidelines for homework:**

• Discuss the problems with your classmates as much as you want, but do your own work and write your own solutions!

• Please take care to present your work in a neat, readable, and logical manner.

• You **must** cite any source that you use for your solutions other than what is contained in the course text.

• You will find the program *Mathematica* extremely helpful to relieve much of the algebra and calculus tedium typically involved in these problems. If you use *Mathematica*, you need to include a printout of your code with your solutions. You will not have access to it during the exams (unless the exams are take-home), so be sure you can perform all of the operations that you use it for by hand.

• In the case of an incorrect solution, I will give credit for arguments and/or illustrations that show you know it is incorrect and why; this goes for the exams as well. I may also reward any effort obviously beyond what is asked for in a problem, such as graphical presentations of solutions, etc.

**Exams:** There will a midterm and a final exam and these will constitute the remaining 40% of your grade. The exams may be in-class or take-home.

**Grades:** The grade breakdown will be: 90-100% A, 80-89% B, 70-79% C, 60-69 D, and F<59%. Final grades will be rounded to the nearest 1% in your favor.

**Supplementary references:**

• D. J. Griffiths, *Introduction to Electrodynamics*, (4th ed. Pearson, 2013). While somewhat below the level of this course, this is probably the best textbook on the topic.

• A. Zangwill, *Modern Electrodynamics*, (Cambridge University Press, 2013). Same level of difficulty as Jackson, but shows many neat applications of the material.

University Required Statements

Academic Honesty: Kansas State University has an Honor and Integrity System based on personal integrity, which is presumed to be sufficient assurance that, in academic matters, one’s work is performed honestly and without unauthorized assistance. Undergraduate and graduate students, by registration, acknowledge the jurisdiction of the Honor and Integrity System. The policies and procedures of the Honor and Integrity System apply to all full and part-time students enrolled in undergraduate and graduate courses on-campus, off-campus, and via distance learning. The Honor and Integrity System website can be reached via the following URL: www.k-state.edu/honor. A component vital to the Honor and Integrity System is the inclusion of the Honor Pledge which applies to all assignments, examinations, or other course work undertaken by students. The Honor Pledge is implied, whether or not it is stated: “On my honor, as a student, I have neither given nor received unauthorized aid on this academic work.” A grade of XF can result from a breach of academic honesty. The F indicates failure in the course; the X indicates the reason is an Honor Pledge violation.

Students with Disabilities: Students with disabilities who need classroom accommodations, access to technology, or information about emergency building/campus evacuation processes should contact the Student Access Center and/or their instructor. Services are available to students with a wide range of disabilities including, but not limited to, physical disabilities, medical conditions, learning disabilities, attention deficit disorder, depression, and anxiety. If you are a student enrolled in campus/online courses through the Manhattan or Olathe campuses, contact the Student Access Center at accesscenter@k-state.edu, 785-532-6441; for K-State Polytechnic campus, contact Academic and Student Services at polytechnicadvising@ksu.edu or call 785-826-2974.

Statement Defining Expectations for Classroom Conduct: All student activities in the University, including this course, are governed by the Student Judicial Conduct Code as outlined in the Student Governing Association By Laws, Article V, Section 3, number 2. Students who engage in behavior that disrupts the learning environment may be asked to leave the class.