Multidisciplinary knowledge in teaching electrodynamics for undergraduate major in optics and photonics

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Abstract: Typical examples of multidisciplinary knowledge in teaching electrodynamics for undergraduate major in optics and photonics is introduced, which could help to inspire the interest for active learning and related disciplinary, and stimulate the consciousness of innovation.

1. Introduction

Electrodynamics is a compulsory course for undergraduate major in optics and photonics in our university. There is usually an interesting and "tough" question arise from the students that why then are required to study this course since they do not major in physics, which actually implies the enthusiasm and activity during the learning process. For years, the answer has been "prepared" to that this course will help to enhance the disciplinary fundamentals for professional curriculum such as laser principles, laser physics, advanced optics, and so on.

Recently, the leading instructor for this compulsory course found that the question could be answered by actively introducing multidisciplinary knowledge, especially the technical milestones achieved through **mutual inspiration** between the professors (researchers) that major in optics/photonics and electronic engineering, by teaching the multidisciplinary knowledge, such as the inspiration from radar technology that excites the innovation of chirp pulse amplification (CPA), which won the honor of Nobel Prize in Physics, would significantly increase the enthusiasm and activity of the students. In this paper, we will introduce the typical multidisciplinary materials that could be used for teaching electrodynamics course for undergraduate major in optics and photonics, which could inspire the student to concentrate their attention on the course and the related disciplinary, and stimulate the consciousness of innovation.

2. Laser development inspired by radar

Large number of the undergraduates will further study laser fundamentals as professional curriculum, even will choose laser as the topic of their undergraduate graduation project and the major during their graduate careers. The chirped pulse amplification (CPA), which was awarded the 2018 Nobel Prize in Physics, is one of the key technics for ultra-intense and ultra-short laser pulse generation, is highly related to laser science and technology. CPA is an excellent topic for the students major in optics and photonics, which is newly included into the course material during the process of preparing for the lessons.

The history and knowledge summarized in reference [1] clearly reveals that the CPA technique was proposed to solve the contradiction between the detection range and resolution in the 1950s, which increased in the performance of Radar system. In the 1980s, this concept was introduced in the field of optics [2], which provides a novel method for achieving ultra-intense and ultra-short laser pulse generation compared with classical mode-locking and/or Q-switching method. After they were taught that CPA technique for strong lasers was radar-inspired, the enthusiasm and activity will be significantly increased.

3. Radar development inspired by optics

Part of the undergraduates will choose physical electronics as the topic of their undergraduate graduation project and the major during their graduate careers, so it would be meaningful to teach the examples that the performance scaling of radar could be inspired by optics. One of the examples is the application of vortex electromagnetic wave in radar. It is known that the vortex electromagnetic wave that carries the orbital angular momentum (OAM) has unique advantage in increasing the detection range and imaging resolution because of the higher dimensional modulation freedom, it is a basic concept that derived from the fundamental of electrodynamics [3]. The application of OAM beam was firstly proposed and achieved as the form of optical beam [4], and has been widely applied in optical communications, laser processing, and scientific research such as atomic physics due to their unique spatial structures.

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In recent years, the concept of OAM beam was broadened to electromagnetic beams [5], the physical principle of radar based on vortex electromagnetic beams was sufficiently investigated, and there have been plenty of research development that involves the application of vortex electromagnetic beam based imaging and rotational Doppler frequency detection with increased performance. After they were taught that OAM beam, which has been the research frontiers of optics and photons for years, can be referred to the design of new type of Radar, the enthusiasm and activity will be significantly increased.

4. Phased array: mutual inspiration

There is growing interesting in investigating and employment of phased array for both radar and laser community. In last century, the technology of phase array radar has significantly changed the performance of radar and even the whole architecture of electronics instrument. In this century, the concept of phased array was introduced to the field of high-power laser technology, which aims at the potential of increasing the output power without significantly loss the beam quality, and tremendous achievements have been obtained in various kinds of lasers due to the breakthrough in phase control technology and so on. Simultaneously, scientists and engineers are also trying to build powerful microwave system based on similar scheme.

Recently, with the rapid development of lidar (Light detection and ranging) and silicon-based photonics, the optical phased array provides a powerful and versatile solution for lidar application. Optical phased array, which combines the multidisciplinary knowledge such as photonics and electronics, is a typical interdisciplinary topic for the students. By learning the operation mechanism of phased array, the student could better understand the fundamentals of a phased array system, the similarities and difference [6].

5. Conclusion and future endeavors

Electrodynamics is set to be a compulsory course for undergraduate major in optics and photonics in our university. Although it is a highly theoretical course, it had been found that the teaching and learning process is not "boring" by innovation in teaching method, for example, problem-based-learning, introducing multidisciplinary knowledge, and analyzing practical engendering projects. The course of electrodynamics could enhance the disciplinary fundamentals for the future study (investigation) in physical electronics and optical engineering.

6. References

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