Directed-Energy Beam Weapons


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This book is dedicated to my son, Sasha

Preface

As we have seen in past decades, the directed-energy weapons (DEWs) are pushing toward a different direction and taking a new approach as directed-energy beam weapon (DEBWs), which is the dawn of new age defenses. This book focuses on new class of weapons that, as we stated, are known as directed-energy beam weapons, which not only have focused on high-energy laser (HEL) but have described particle-beam weapons (PBWs) as well as kinetic energy weapons (KEWs).

This book also contains two new chapters: high-power microwave (HPM) as weapon of new approach to directed beam weapons and a new high-energy wave known as scalar longitudinal wave (SLW) which has a new potential as weapon of directed energy.

The only difference between these two beam weapons and high-power or high-energy lasers is that these types of directed-energy weapons do not suffer from the deficiency of thermal blooming seen in high-energy laser beams when such laser beam travels through atmosphere, in particular when they propagate as either ground-based laser (GBL) or airborne laser (ABR) systems.

Last one decade or so has also seen emergence of a new class of weapons known as directed-energy weapons (DEWs), leading to enhanced global interest from scientists and engineers in DEW development. Lasers, high-power microwaves, and high-energy particle beams have been exploited for DEW development. These weapons, with the exception of particle-beam weapons (PBWs) and laser-induced plasma channel (LIPC) weapons, generate streams of electromagnetic energy that can be precisely directed over long distances to disable or destroy intended targets.

Laser is no longer confined to premises of prominent research centers like Bell Laboratories and Hughes Research Laboratories and major academic institutes like Columbia University, USA, as it was in its early stages of development and evolution. In the last five decades, after Theodore Maiman demonstrated the first laser in May 1960 at Hughes Research Laboratories, there has been an explosive growth in industrial, medical, scientific, and military applications of lasers. Application areas continue to grow with every passing day.

Lasers have been used in various military applications since the early days of development that followed their invention. There has been large-scale proliferation of lasers and optronic devices and systems for applications like range finding, target designation, target acquisition and tracking, precision-guided munitions, and so on during the 1970s and the 1980s.

These devices continue to improve in performance and find increased acceptance and usage in contemporary battlefield weaponry. Technological advances in optics, optoelectronics, and electronics leading to more rugged, reliable, compact, and efficient laser devices are largely responsible for making these indispensables in modern warfare.

Last one decade or so has also seen emergence of a new class of weapons known as directed energy weapons (DEWs) leading to enhanced global interest from scientists and engineers in DEW' development. Lasers, high-power microwaves and high-energy particle beams have been exploited for DEW development. These weapons, with the exception of Particle Beam Weapons (PBWs) and Laser-Induced Plasma Channel (LIPC) weapons, generate streams of electromagnetic energy that can be precisely directed over long distances to disable or destroy intended targets.

Although scalar longitudinal wave (SLW) phenomenon is nothing new since Tesla introduced such wave more than a century ago, a lot of attention has been paid to this particular generation of wave in recent years, where it can be derived easily from the more complete equation of Maxwell using vector calculus and shows one more term added to Maxwell-Ampere equation, as illustrated in the new chapter of this book under the title of "All About Wave Equations."

High-power electromagnetic pulse (HPEP) is covered under the chapter with the title of "High Power Microwave" presented by Dr. Carlo Kopp.

High-power electromagnetic pulse generation techniques and high-power microwave technology have matured to the point where practical E-bombs (electromagnetic bombs) are becoming technically feasible, with new applications in both strategic and tactical information warfare. The development of conventional E-bomb devices allows their use in nonnuclear confrontations. This paper discusses aspects of the technology base and weapon delivery techniques and proposes a doctrinal foundation for the use of such devices in warhead and bomb applications.

High-power microwave (HPM) sources have been under investigation for several years as potential weapons for a variety of combat, sabotage, and terrorist applications. Due to classification restrictions, details of this work are relatively unknown outside the military community and its contractors. A key point to recognize is the insidious nature of high-power microwave (HPM). Due to the gigahertz-band frequencies (4 to 20 GHz) involved, HPM has the capability to penetrate not only radio front ends but also the most minute shielding penetrations throughout the equipment. At sufficiently high levels, as discussed, the potential exists for significant damage to devices and circuits. For these reasons, HPM should be of interest to the broad spectrum of EMC practitioners.

The chapter under the title of "Particle Beam Weapons" is presented by Dr. Richard M. Roberds. Although much has been written on the high-energy laser (HEL), this category of directed-energy weapon appears to be well understood

by members of the defense community. Laser weapons have been under active development for 20 years and easily constitute the most advanced of the directed-energy devices.

In contrast, the particle-beam weapon (PBW) has been the "sleeper" among directed-energy weapons until very recently. Enshrouded in secrecy, it began as a project sponsored by the Advanced Research Projects Agency (now called Defense Advanced Research Projects Agency better known as DARPA) as early as 1958, 2 years before the first scientific laser demonstration in 1960. Code-named Seesaw, the project was designed to study the possible use of particle beams for ballistic missile defense. Today while its development lags that of the high-energy laser, the particle-beam weapon is viewed by some military technicians as the follow-on weapon to the laser, because of its higher potential lethality.

Generally speaking, this book will provide a holistic approach to new-generation Star Wars weapon system for the readers who would like to extend their knowledge beyond just high-energy laser (HEL) as directed-energy weapon as it was introduced by this author in a similar book published by Springer in 2016.

Albuquerque, NM, USA B. Zohuri
2016

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I am indebted to the many people who aided, encouraged, and supported me beyond my expectations. Some are not around to see the results of their encouragement in the production of this book, yet I hope they know of my deepest appreciations. I especially want to thank my friend Bill Kemp, to whom I am deeply indebted, who has continuously given his support without hesitation. He has always kept me going in the right direction.

Above all, I offer very special thanks to my late mother and father and to my children, in particular my son, Sasha. They have provided constant interest and encouragement, without which this book would not have been written. Their patience with my many absences from home and long hours in front of the computer to prepare the manuscript are especially appreciated.

About This Document

This section describes the document's purpose, scope, and audience; lists documents that provide additional, related information; and provides definitions of terms.

Purpose

The purpose of this document is to describe dimensional analysis, similarity, and modeling methods.

Contents

About the Author

Bahman Zohuri currently works for Galaxy Advanced Engineering, Inc., a consulting firm that he started in 1991 when he left both the semiconductor and defense industries after many years of working as a chief scientist. After graduating from the University of Illinois in the field of physics and applied mathematics, he then went to the University of New Mexico, where he studied nuclear engineering and mechanical engineering. He joined Westinghouse Electric Corporation, where he performed thermal hydraulic analysis and studied natural circulation in an inherent shutdown, heat removal system (ISHRS) in the core of a liquid metal fast breeder reactor (LMFBR) as a secondary fully inherent shutdown system for secondary loop heat exchange. All these designs were used in nuclear safety and reliability engineering for a self-actuated shutdown system. He designed a mercury heat pipe and electromagnetic pumps for large pool concepts of a LMFBR for heat rejection purposes for this reactor around 1978, when he received a patent for it. He was subsequently transferred to the defense division of Westinghouse, where he oversaw dynamic analysis and methods of launching and controlling MX missiles from canisters. The results were applied to MX launch seal performance and muzzle blast phenomena analysis (i.e., missile vibration and hydrodynamic shock formation). Dr. Zohuri was also involved in analytical calculations and computations in the study of nonlinear ion waves in rarefying plasma. The results were applied to the propagation of the so-called soliton waves and the resulting charge collector traces in the rarefaction characterization of the corona of laser-irradiated target pellets. As part of his graduate research work at Argonne National Laboratory, he performed computations and programming of multi-exchange integrals in surface physics and solid-state physics. He earned various patents in areas such as diffusion processes and diffusion furnace design while working as a senior process engineer at various semiconductor companies, such as Intel Corp., Varian Medical Systems, and National Semiconductor Corporation. He later joined Lockheed Martin Missile and Aerospace Corporation as senior chief scientist and oversaw research and development (R&D) and

the study of the vulnerability, survivability, and both radiation and laser hardening of different components of the Strategic Defense Initiative, known as Star Wars.

This included payloads (i.e., IR sensor) for the Defense Support Program, the Boost Surveillance and Tracking System, and Space Surveillance and Tracking Satellite against laser and nuclear threats. While at Lockheed Martin, he also performed analyses of laser beam characteristics and nuclear radiation interactions with materials, transient radiation effects in electronics, electromagnetic pulses, system-generated electromagnetic pulses, single-event upset, blast, thermo-mechanical, hardness assurance, maintenance, and device technology.

He spent several years as a consultant at Galaxy Advanced Engineering serving Sandia National Laboratories, where he supported the development of operational hazard assessments for the Air Force Safety Center in collaboration with other researchers and third parties. Ultimately, the results were included in Air Force Instructions issued specifically for directed-energy weapons operational safety. He completed the first version of a comprehensive library of detailed laser tools for airborne lasers, advanced tactical lasers, tactical high-energy lasers, and mobile/tactical high-energy lasers, for example.

He also oversaw SDI computer programs, in connection with Battle Management C^3I and artificial intelligence, and autonomous systems. He is the author of several publications and holds several patents, such as for a laser-activated radioactive decay and results of a through-bulkhead initiator. He has published the following works: *Heat Pipe Design and Technology: A Practical Approach* (CRC Press); *Dimensional Analysis and Self-Similarity Methods for Engineers and Scientists* (Springer); *High Energy Laser (HEL): Tomorrow's Weapon in Directed Energy Weapons*, Volume I and Volume II (Trafford Publishing Company); and recently the book on the subject *Directed Energy Weapons and Physics of High Energy Laser* with Springer. He has other books with Springer Publishing Company, such as *Thermodynamics in Nuclear Power Plant Systems* (Springer) and *Thermal-Hydraulic Analysis of Nuclear Reactors* (Springer).