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DEVELOPMENT OF LASSIM SOFTWARE PROTOTYPE FOR SIMULATING PHYSICAL CHARACTERISTICS OF LASER DEVICES

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Abstract. This paper presents a software prototype LasSim, developed for numerical modeling and computer simulation of physical processes in gas discharge, encountered in various laser systems, discharge devices, electron-ion devices. The prototype is designed on .NET Framework, WPF and C# technologies and gives the opportunities for installing and managing the model simulation processes.

Key words: computer simulation, .NET Framework.4, WPF technology, laser software

1. Introduction

The motivation of development and application of simulation software in physics and engineering is determined by a significant reduce in price and time with respect to experiments, opportunity to direct and easy investigation and prediction of the studied process behavior, evaluating the influence of parameters and initial conditions, estimating the performance of components, devices or complex systems. Many software tools and systems were created in recent years, both open and commercial source.

A brief survey of the existing ones shows a large variety of approaches, modeling methods and applied computer technologies. There are used common and specialized simulation environments and languages for modeling and simulation of large number of practical and educational problems. One of the more popular is

Modelica (with CATIA Systems, LMS AMESim, MathModelica simulation environments) [1], a package and object-oriented equation based language to conveniently model physical systems with mechanical, electrical, electronic, thermal, control, electric power subcomponents, etc. COMSOL Multiphysics (FEMLAB) [2] is an example of complex simulation Java software, based on finite element analysis for various physics and engineering applications, including a specific Plasma model, which is applicable in low temperature plasmas and laser physics. Another important environment with practical and educational use is the open project Open Source Physics [3, 4], which allows to develop and implement the reusable libraries for numerical simulations, supported by Easy Java Simulations graphical environment that generates automatically codes based on these libraries.

Besides the upper described common physical software, a number of more specialized packages in the area of laser simulation and modeling are developed. The Astrokettle Algorithms [5] has a tool based on the Boltzmann equation for calculation of the electron energy distribution function and collision rate coefficients in the gas-discharge or electron beam formed plasma under arbitrary non-stationary conditions. Also a plasma-chemical kinetics simulation in KrF* excimer pulse laser, realized on the simultaneous solution of over 300 algebraic-differential equations is available. Laser software LASCAD [6] provides several effective simulation tools for laser cavity analysis and design of solid-state type lasers, based on finite element analysis and other simulation techniques. For other laser software see for instance [7-13].

In this paper we present a software prototype LasSim, designed for simulation of physical processes in gas discharge, encountered in some types of gas lasers, gas laser and plasma-ion devices. The prototype is realized for equation-based simulation by using analytical and numerical models of the characteristics of different laser devices, developed in Laboratory of Metal vapor lasers, Institute of Solid State Physics, Bulgarian Academy of Sciences.

2. Determining functionalities and LasSim common structure

LasSim is realized as Windows application presenting an open program model and environment for registration and running available simulation modules (coded algorithms). Modules are console applications that can be written independently by using Microsoft Visual Studio or other appropriate software. They could be reusable, created by the user or of other kind. Any simulation module can perform given model simulation, by using its corresponding input files and generates the output results files.

Figure 1 shows the Use Case UML diagram for the main functionality of LasSim.

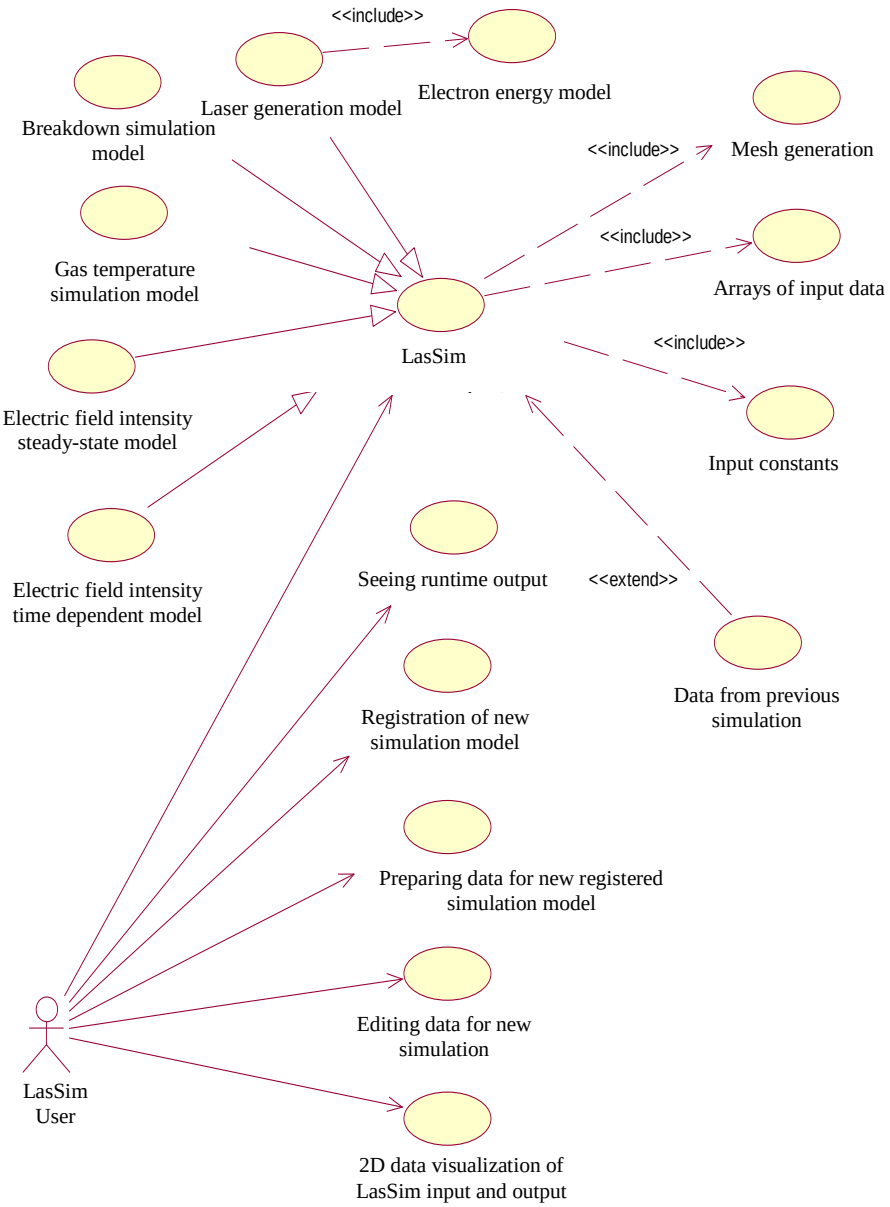

Figure 1. Use Case diagram for LasSim.

Any simulation model can use the input or output files from other simulation, by defining the latest as parameters during the registration and adjustment setup when necessary. A common Command file is used to save the information about all registered simulation models and its parameters.

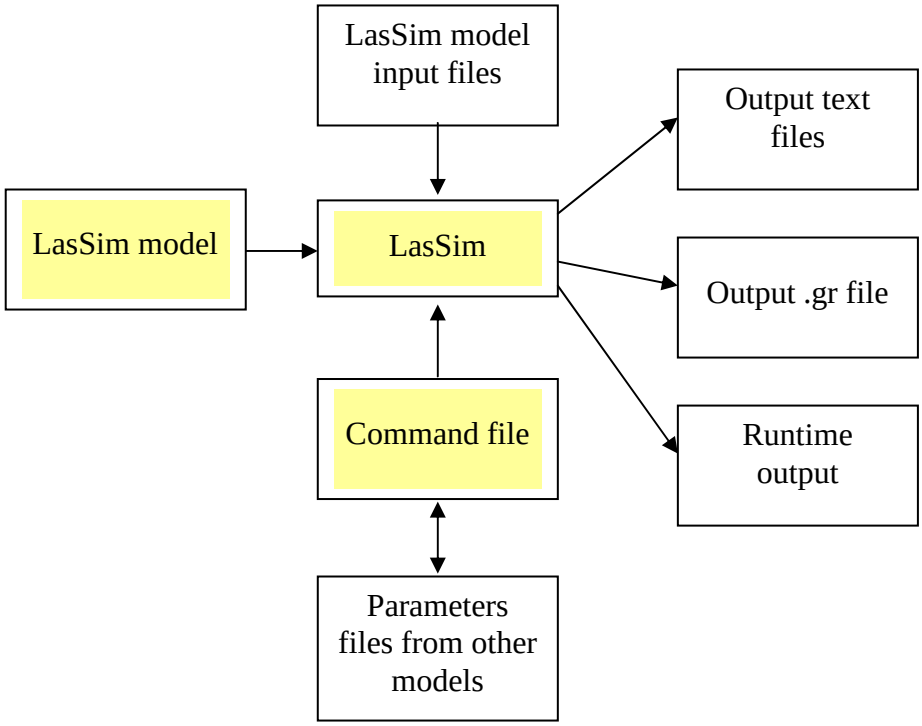

Figure 2. Common structure of LasSim interoperability.

The output files can be of the following three types: text files with arbitrary structure, *.gr files to be visualized and common text Runtime output, which is realized as a common window to show running time of any simulation and error messages from the operating system when they occur. The common interoperability between the different type of applications and I/O files is shown in Figure 2.

3. Used technologies and model applications

In order to develop a flexible and extendable software system with an open programming model and easy to manage processes we chose a new generation Microsoft .NET Framework 4., Windows Presentation Foundation (WPF) technologies. Also C#, Microsoft Visual Studio 8/Fortran, Visual Studio 2010 and some web applications are used. However there is no restriction about the programming languages for creation of model applications.

The .NET Framework 4. [15] operates as Common Language Runtime (CLR) providing an abstraction layer over the operating system. It includes a Base Class Libraries – pre-built code for common low-level programming tasks. These capabilities allow application of development frameworks and technologies – reusable, customizable solutions for larger programming tasks. The applications are compiled to the platform-independent language, called CIL (Common Intermediate Language). During the execution process the CIL code is automatically compiled by CLR for current hardware platform and user operating system. The key features of .NET Framework version 4 are: platform independence, language independence, improved security, interoperability, etc.

The WPF is component of Microsoft .NET Framework 4, which supports UI, media, documents, hardware acceleration, vector graphics, scalability to different form factors, interactive data visualization, and superior content readability. More about WPF can be found at [16].

Over 15 models are implemented in LasSim prototype software. The model applications are as follows (see also Figure 1): Equation-based model for numerical simulation of the steady-state potential and intensity of the electric field in Helium-cadmium laser device; model for numerical simulation of the electric field intensity in time and space in the longitudinal section of the copper bromide laser; gas temperature models in the cross-section of the laser tube, based on analytic models for copper bromide laser, deep ultraviolet copper bromide laser and atomic helium strontium bromide laser; model for simulating the stability of the argon radio-frequency discharge (breakdown conditions), etc.

The simulation models are realized in accordance with the theoretical results, main of them are published in [16-21].

4. LasSim functionalities

The main functionalities of the prototype are (see also Figure 1):

- Running the integrated models for different simulations; controlling the running time of the processor, obtaining the error messages when available

- Installing and removing model applications to the LasSim environment; this procedures require also the installation of the necessary input files, including results from other models
- Possibility of post-processing and using the results from previous simulations in a new simulation model
- 2D visualisation of the input or output file. An example is given in Figure 3.
- Possibility of repeatedly execution of a given model
- Saving the results of the simulation as a *.zip file [22], printing, etc.
- Using a Help system with an User's Guide and texts of the authors publications in Bulgarian and English.

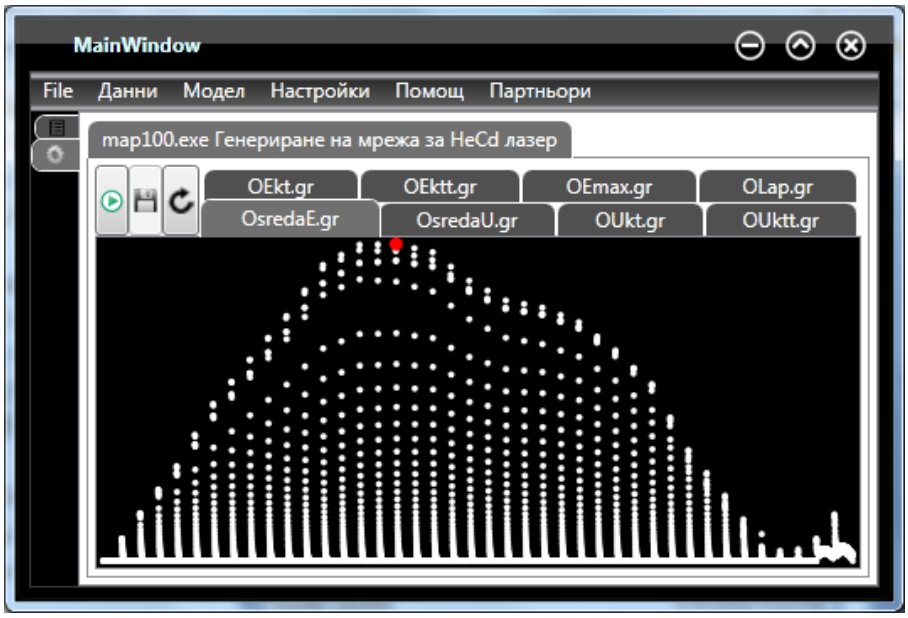

Figure 3. Graphical representation of electric field intensity in the center of the CuBr laser at different delays in time, obtained by the LasSim prototype.

5. Conclusion

The developed LasSim prototype is an initial working version of the conceived software for simulating various laser devices. It is expected to be of big interest for modeling existing and designing and prediction of characteristics of future devices.

6. Acknowledgements

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РАЗРАБОТКА НА СОФТУЕРЕН ПРОТОТИП LASSIM ЗА СИМУЛИРАНЕ НА ФИЗИЧНИТЕ ХАРАКТЕРИСТИКИ НА ЛАЗЕРНИ УСТРОЙСТВА

Снежана Гочева-Илиева, Чавдар Кулин

Резюме. В тази работа е представен софтуерен прототип LasSim, разработен за числено моделиране и компютърни симулации на физичните процеси в газов разряд, срещащ се в различни лазерни системи, газоразрядни устройства, електронни и йонни технологии и др. Прототипът е реализиран с .NET Framework, WPF и C# технологии и дава възможност за инсталиране и управление на процеси от моделните приложения.