SUMMARY OF 1990 CODE CONFERENCE *

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Abstract

The Conference on Codes and the Linear Accelerator Community was held in Los Alamos in January 1990, and had approximately 100 participants. This conference was the second in a series which has as its goal the exchange of information about codes and code practices among those writing and actually using these codes for the design and analysis of linear accelerators and their components. The first conference was held in San Diego in January 1988, and concentrated on beam dynamics codes and Maxwell solvers. This most recent conference concentrated on 3-D codes and techniques to handle the large amounts of data required for three-dimensional problems. In addition to descriptions of codes, their algorithms and implementations, there were a number of paper describing the use of many of the codes. Proceedings of both these conferences are available[1,2].

Introduction

Finding a coherent scheme of classification for the many codes discussed at the conference is tricky at best. The 3D/2D breakdown is insufficient, so we have broken the codes into two broad categories, namely codes that solve for electromagnetic fields and push particles in those fields, and codes that we will call beam optics codes. The latter category includes codes that are based on some model of beam interactions with their surroundings. We present the codes discussed in the conference in these two broad categories in two tables, Table I and Table II, respectively.

Field and Particle Solvers

In the design of accelerators we are interested in moving charged particles through electromagnetic fields. The ordering of the codes in Table I has roughly to do with whether the principal emphasis of the code is on the fields or the particles. Thus the codes MAGNUS-3D, TOSCA, HFSS, and MSC/EMAS deal almost exclusively with electromagnetic fields, while the particle-in-cell (PIC) codes such as ARGUS, SOS, and QUICKSILVER are equally concerned with particles and fields, and finally codes such as DPC, WARP, and ELBA, used in the analysis of very high current beams, are principally concerned with the motion of the particles. In Tables I and II all those code names set in boldface type are to be found in the new compendium[3] of codes published by the Los Alamos Accelerator Code Group for the DOE Office of High Energy and Nuclear Physics. Inclusion in Ref. 3 does not necessarily constitute a recommendation or endorsement of a given code. However, additional details on each code are available in the compendium; details include code function, purpose, history, author, references, status, individual maintaining the code, and individual distributing the code.

*Work supported and funded by the U.S. Department of Energy, Office of High Energy and Nuclear Physics.

The column labeled $\partial/\partial t$ in Table I is meant to indicate whether the code is a static solver (entry 0), a sinusoidal state solver (entry ω_0), or a general time dependence solver (entry x). An entry in the column labeled ω_λ means that an eigenvalue problem can be solved by the code. The FD/FE column indicates whether finite differences or finite elements are being used, respectively. An entry in the column labeled m_{PIC} indicates that particle motion is tracked; if the entry is ∞, then the motion is non-self consistent, i.e., the motion is prescribed.

The three-dimensional codes presently in use by our community have typically come from either the accelerator community or from the plasma physics community. Though the codes arose initially from differing computational requirements, as accelerator currents become more intense and plasma effects become more important, we see a convergence in the capabilities of these codes. Now emerging are codes from commercial sources, again arising from differing computational needs, but holding some promise for the accelerator community. The code MSC/EMAS is a commercial 3-D time- and frequency-domain solver from the MacNeal-Schwendler Corporation, arising from the desire to solve three-dimensional time-dependent problems involving solid-state materials. The HFSS code (not in fact presented to the conference) was written by the Ansoft Corporation for sale by the Hewlett-Packard Corporation, and is intended to solve three-dimensional scattering matrix problems.

Beam Optics Codes

The beam optics field has seen quite a revolution in the past decade, branching out from linear matrix transformations and from numerical ray tracing. In this time interval we have seen the introduction of Lie-algebraic methods into the field, and more recently the differential-algebra approach has been introduced. Also introduced in this decade has been the use of moments to high order to describe beam behavior.

Emphasis these days is on higher-order effects, not just the dependence on the first power of position and momentum. All of the codes listed in Table II have some higher-order capability, and all have some space-charge model incorporated. As in Table I, a code name set in boldface means that it is listed in the code compendium, Ref. 3.

Miscellaneous

There is always some item that just won't fit into a tidy classification scheme, and in the codes discussed at the conference the code FELPPC was a good example. FELPPC stands for Free-Electron Laser Physical Process Code and is a code which incorporates models of the component parts of a free-electron laser into a code which can perform a great many simple calculations to determine mass, cost, and size of system with specified performance. Additionally, the suite of codes CAVGEN, TRACEX, and CAVDYN being used at FNAL for linac tolerance simulations do not fall neatly into the Table I, Table II scheme. Reference 2 contains the details of these codes.

Table I. Field and Particle Codes

Code Name	3D	2D	$\partial/\partial t$	ω_λ	FD/FE	m_{PIC}	Notes
GFUN	x		0				Magnet design, volume integral
PE2D		x	ω_0		FE		Eddy current
CARMEN	x		ω_0		FE		Eddy current
TOSCA	x	x	0		FE		Magnet design
MAGNUS-3D	x		ω_0		FE		Magnet design, eddy current
HFSS	x		ω_0		FE		S parameters
MSC/EMAS	x	x	x	x	FE		
ARCHON		x	x		FD	∞	Wakefield, parallel, dielectrics
ARRAKIS		x	x		FD	∞	Wakefield, parallel, dielectrics
AMOS		x	x		FD	∞	Wakefield, losses, dielectrics
MAFIA 3.0	x			x	FD	∞	
MAFIA 3.1	x	x	x	x	FD	x	
MASK		x	x		FD	x	
CONDOR		x	x		FD	x	
MAGIC		x	x		FD		
ARGUS	x		x	x	FD	x	
SOS	x		x	x	FD	x	
QUICKSILVER	x		x		FD	x	
DPC/ST/ENV	x		x			x	Intense electron beam motion
ELBA	x		x			x	Intense beam motion
WARP	x		x			x	High current ion beams

Table II. Beam Optics Codes

Code Name	Notes
PATH	3D space charge.
MARYLIE	Lie-algebra based, 3rd order optics, higher order for some elements.
BEDLAM	Moment based, Lie-Poisson integration for numerical stability, 3D space charge model.
COSY INFINITY	Differential algebra based, arbitrary order possible.
TRIBO	Beam optics to high order including 2D and 3D space charge.

Conclusion

A paper summarizing a conference involving discussions of a multitude of codes cannot do justice to even a handful of them. The proceedings are the best summary of the conference, providing the interested individual with detailed information and references. As a guide to those interested in this subject, We include here a list of the papers to be found in the Proceedings of the Conference on Codes and the Linear Accelerator Community, Ref. 2.

- Solving Maxwell's Equations in 3D and 2D by means of MAFIA
- Three-Dimensional Modeling of Accelerators
- MAGIC User's Group Software
- Magnet Design Using Finite Element Software
- MAGNUS-3D: Improvements in Three-Dimensional Magnet Calculations
- Study of Separators Using Numerical Simulations
- ELBA—A Three-Dimensional Particle Simulation Code
- Extraction Induced Emittance Growth for Negative Ion Sources
- WARP: A 3D (+) PIC Code for HIF Simulations
- COSY INFINITY, A New Arbitrary Order Optics Code
- New BEDLAM
- Analytic Transfer Maps for Lie Algebraic Design Codes
- Integrated Numerical Experiments (INEX) and the Free-Electron Laser Physical Process code FELPPC
- Accelerator Code Simulation of FXR Transport
- Coupled Cavity 3-D Codes for Linac Tolerance Simulations
- Applications of 3-D Maxwell Solvers to Accelerator Design
- The AMOS Wakefield Code
- Some Initial Results from the New SLAC Permeameter
- Numerical Simulation of Cross Field Amplifiers
- Simulation of IFR Transport in the Sandia Recirculating Linear Accelerator Using ELBA
- Architecture and Computing Philosophy of the QUICKSILVER, 3D, Electromagnetic, Particle-In-Cell Code
- Numerical Simulations of Beam Dynamics in the Spiral Line Induction Accelerator Using ELBA
- Three Dimensional TOSCA Calculations on the TRIUMF Second Arm Spectrometer Magnet
- Comparison of Results Between Different Precision MAFIA Codes
- Space Charge Models and "PATH"
- Wakefield Calculations on Parallel Computers
- Analysis of Electromagnetic Resonant Cavities and Waveguides Using MSC/EMAS
- PARMILA Documentation
- Aberrations of Electrostatic Lenses Consisting of Rotationally–Symmetric Electrodes
- Codes Maintained by the LAACG at the NMFECC
- TRIBO, a Program to Determine High-Order Properties of Intense Ion Beams
- Fifth-Order Aberrations in Magnetic Quadrupole-Octupole Systems

References

1. Charles R. Eminhizer, Ed., *AIP Conference Proceedings 177: Linear Accelerator and Beam Optics Codes, La Jolla Institute 1988*, (American Institute of Physics, New York, 1988).
2. Richard K. Cooper, Compiler, *Proceedings of the Conference on Computer Codes and the Linear Accelerator Community*, Los Alamos National Laboratory, January 22-25, 1990, LA-11857-C.
3. H. K. Deaven and K. C. D. Chan, Eds., *Computer Codes for Particle Accelerator Design and Analysis: A Compendium*, LA-UR-90-1766, May 1990.