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SUMMARY FOR THE WORKING GROUP ON LINAC CODES*

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The linac codes group discussed two main topics: (1) the PARMTEQ codes and their environment and (2) limitations of the linac simulation codes.

The PARMTEQ Codes and Their Enviroment

The RFQ design program PARMTEQ[1] is used at many laboratories, both for the detailed cell generation and for multiparticle simulation to test the design. However, RFQ beam-dynamics design procedure requires the determination of a large number of parameters to produce the required focusing, adiabatic bunching, and acceleration of the beam. Frequently, both high beam intensity and low emittance are desired at minimum values for peak surface field, vane length, and rf power. RFQ designers have found that preprocessor design codes are almost a necessity for these cases. Although the best design technique is not yet known, codes such as CURLI and RFQUIK, written originally by T. Wangler at Los Alamos, allow the designer to determine the space-charge limits and to achieve an acceptable compromise among the design parameters. The purpose of CURLI is to evaluate the transverse and longitudinal current limits as a function of the RFQ parameters, thereby allowing the designer to choose an RFQ design with adequate focusing for the anticipated space-charge forces. The program RFQUIK is then used by the designer to choose a complete set of input data for PARMTEQ. The input data contain the adiabatic bunching prescriptions and other rules of thumb for choosing parameters. Tradeoffs between beam performance and RFQ length and power can be chosen by the designer. Many preprocessor codes have been written at other laboratories, some with rather different objectives, such as the design of short, heavy ion linacs where space charge can be ignored.

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The PARMTEQ code itself, universally used, serves as a useful basis and standard of comparison among various groups designing RFQs. Recent work has allowed different pole tip designs to be treated with more accuracy, using a 4- or even an 8-term potential function. Some versions have included a more accurate representation of the radial matcher and a variation of the voltage along the vane.

Output processor codes, which use the output results from PARMTEQ as their input, are useful after an RFQ beam-dynamics design has been chosen. At Los Alamos, such a program was written by K. Crandall to perform a variety of functions as chosen by the designer. The most important function is the choice of actual vane geometry and the adjustment of RFQ parameters to produce the design values of the lowest-order multipoles. An additional output program is required to produce the vane construction information for the numerically controlled milling machine.

A program of value for RFQ cavity design and tuning has been written by R. Hutcheons at Chalk River.[2] This program is based on a coupled circuit model and contains enough information for studies of the effects of higher-order modes.

The Working Group discussed the value of maintaining a standard version of the PARMTEQ code to allow easy comparison of any RFQ design at all laboratories. The concensus was that the existence of a standard code is valuable, but should not hinder new code developments.

Limitations of the Linac Simulation Codes

The number of particles required for adequate calculation of space-charge effects is an important consideration for numerical simulation studies. The consensus of the group was that for detailed transfer maps with space charge, many particles are required. It was reported at this meeting[3] that 90 000 particles for programs like CHARLIE may even be inadequate for accurate transfer maps that allow determination of space-charge effects. However, for describing the average properties of the beam, including the second moments of the distribution and the rms emittance, many fewer particles, often no more than about 10^3, are adequate for obtaining reproducible and accurate results. PIC-type codes can calculate second moments to good (1%) accuracy, but when good resolution of sharp beam edges is necessary, PIC codes do not perform adequately.

The physics contained in linac codes like PARMILA,[4] PARMELA,[5] and PARMTEQ[1] was felt to be adequate for description of the small amplitude particles in the beam, but probably was inadequate for the larger amplitude particles that contribute to beam halo. Accurate description of the halo will require putting all sources of nonlinear fields into the codes, including both space-charge and image forces. The effect of the image forces is not simple to analyze because it depends on the detailed geometry and on the relative alignment of the beam and accelerator. No bunched-beam image-force analyses have been applied to these codes. An encouraging result about the image-charge effect comes from the studies of Celata,[6] which indicate that even for off-axis beams, image-charge effects may only become important at very low values of the space-charge tune depression. Neutralization may persist from the LEBT into the RFQ. At present, we assume no neutralization, and it is not clear how to handle this possible effect.

A few comparisons of these linac codes with experimental measurements have been made, and more should be available within the next few years. R. Jameson described the comparison of PARMILA with measurements on the CERN linac,[7] where it was concluded that the experimental emittance results could be explained from the PARMILA runs, with reasonable assumptions about beam misalignment and mismatch. PARMTEQ calculations have agreed well with measured longitudinal distributions,[1] even with excitation errors. Comparison with transverse measurements have also been made, and the agreement has been good.

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