P2.7

"PAPA - A Particle Tracing Code in PASCAL"

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Introduction

PAPA is a new PArticle tracing code in PAscal, developed at NCLR, the Dutch Center for Laser Research.

Keywords for the PAPA program are:

- *Modern, Clear and Consistent Programming Style*
- *Accessibility for other users*
- *Modular Setup - Flexibility*
- *Ease in use*
- *Good Documentation*
- *PASCAL Compatibility*

The current version of PAPA offers a solid base for a new, modern and convenient particle tracing code, to be used for simulations of all kinds of linear accelerator applications, including photo cathode injectors. It is intended to be a public domain code.

Program Setup and Structure

Figure 1 shows a schematic picture of the program's hierarchy.

To achieve a good **compatibility** of the PASCAL source, we only used **standard Pascal** statements. This approach unfortunately cancels much of the power and charm of modern compilers. The action taken by PAPA is therefore restricted to the creation of an ASCII output file, which can be processed by arbitrary other routines. Currently we do the **graphics** on an IBM PC, using fast and convenient routines we wrote in Turbo Pascal. In the future we will probably also create C-versions in a UNIX environment, for use on a DECStation 3100. A fancy option is the creation of a **red/green** picture, which allows the user to see a **stereoscopic 3D-view** of the particle dynamics.

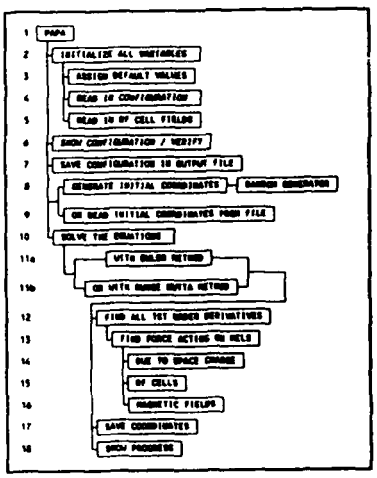


Figure 1. A simple scetch of PAPA's hierarchy.

Mathematical Model

In the PAPA code, an electron pulse is represented by a limited number of uniformly charged, rigid but transparent clouds, called mels ('macro electron'). They have a spherical shape in the lab frame. Mels appeared to be a succesful solution to the 'particle collision problem', since the repelling forces between them reduce to zero when they approach each other closely, see figure 2. Their radius is recalculated continuously, to prevent a limitation of the force interactions.

The equations of motion of $\mathcal{N}$ mels can be written as a set of $6\mathcal{N}$ first order DE's, which is solved in this general form, by either an *Euler* or a *4th order Runge Kutta* routine. PAPA simulations showed that using the Runge Kutta routine in stead of the Euler routine allows a more than forty times larger step size, which results in a more than ten times faster speed, compared to many other particle tracing codes. The modular setup of PAPA allows very easy addition of other numerical routines.

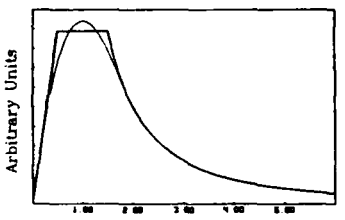
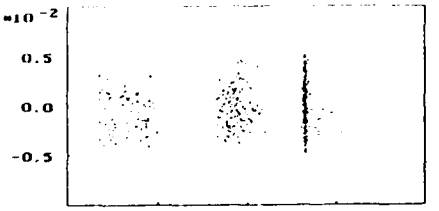


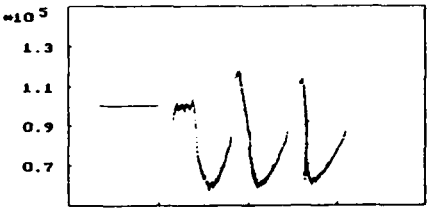
Figure 2. Thick line: repelling force [a.u] between two charged spheres. Thin line: PAPA approximation.

An Illustration

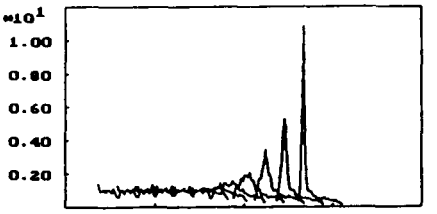
These plots show a typical result of a 1 A 100kV pulse which is bunched by a 40 MHz RF cell.



Side view: mels' z-coordinate [m] vs. their z-coordinate [m] at three positions along the optical axis.



Mels' energy [eV] vs. z-coordinate [m].



Current envelope [A] along the pulse, for different z [m].

RMS emittance [m.rad] along z [m].

Other Options

Accessibility The PAPA source code is well commented. Comments refer directly to the separate documentation.

Input File Translation PAPA can translate the code in the input file into a detailed hardware description in plain English on the computer screen. A useful help, which reduces errors.

Cathodes Optionally, all forces on the mels are ignored as long as their z-coordinate is smaller than zero. This allows the simulation of electrons emerging from a cathode surface. If the cell field files are filled with the electrostatic field distribution of a cathode-grid-anode configuration, PAPA could also be used as a sort of thermionic electron gun simulator, including pulse effects.

Continued runs Each cluster in the PAPA output file can easily serve as input for a continued run. This allows efficient and flexible simulations.

Step Size Reduction A step size reduction happens automatically as soon as one of the mels finds itself inside an RF cavity. The amount of reduction is specified by the user.

Easy Cell Field Input PAPA needs no information about the number of 'rows' and 'colums' in cell field files, since it finds this out by itself. The cell fields can be mapped on the screen.

Output The format of the output file makes it both suited as a hard copy for direct reference, and as a plot file for graphic routines.