The Particle-Core Model of Halo Formation in RMS Mismatched Beams

Robert D. Ryne

In this exercise you will run a code `halo.f` which simultaneously integrates the rms envelope equations of a mismatched particle beam along with the trajectories of 32 test particles. A constant, linear focusing force is present. In addition, the test particles feel the self-fields of the beam core. The core is assumed to have uniform density, hence the electric field is linear inside the core and varies as 1/r outside the core.

The syntax of the input file is:

```
tfin ns nprnt nskip eta r0
```

where

- tfin=length of simulation in time
- ns=number of steps
- nprnt: to print every nprnt steps
- nskip: to skip this number of steps before printing every nprnt steps
- eta=tune depression
- r0=initial envelope size (where 1 corresponds to a matched beam)

The input file is called `halo.in`, and the output file called `halo.out`. For the following problems you will need to copy `halo_a.in`, `halo_b.in`, etc., to `halo.in` prior to execution.

- **Problem 2.1** (use `halo_a.in`)
  Integrate the system with a tune depression $\eta = k/k_o = 0.8$ and $r(0) = 0.651$. The units in this example have been selected so that a matched beam would have $r = 1$, so the choice $r(0) = 0.651$ represents a mismatched beam for which the initial beam size is 0.651% of the matched beam size.

  The input file for this problem is set so that the test particle's coordinates and momenta are written each time the beam core goes through a minimum. Make a stroboscopic plot by plotting columns 2 and 3 of the output file. Note the core trajectories, the large-amplitude trajectories (they look like peanuts), the period-2 resonance, and the separatrices. Use different values of `nskip` (for example, `nskip=25` and `nskip=50`) to see how the figure changes.

- **Problem 2.2** (use `halo_b.in`)
  Next you will increase the tune depression to the point that chaos begins to emerge in portions of the phase space. For this case, $\eta = k/k_o = 0.4$ and $r(0) = 0.607$. Observe the chaotic region in the stroboscopic plot.

- **Problem 2.3** (use `halo_c.in`)
  Run the case $k/k_o = 0.1$ and $r(0) = 0.577$. This value of k/k_o corresponds to the space charge dominated regime. Observe the increased size of the chaotic region. At the strobe times the core is at its minimum value of 0.577. Comment on the amount of space between the edge of the core and the chaotic region. Do you think this would affect the ease with which particles are able to migrate from the core to the chaotic region and hence to large amplitude? Use gnuplot to zoom in and plot small scale structures in the stroboscopic plot.