This code can be used for the arbitrary bunch lengthening study in the presence of passive harmonic cavity. Note that the beam loading of MC is not considered in this version.

The details of algorithm about this semianalytical code can be found in [T. He, et.al., Phys. Rev. Accel. Beams 24 044401 (2021)].

How to run this code?

1 Parameters setting.

```
% HALF
sigma_t = 10e-12;   % initial set rms bunch length  in ps
sigma_E = 6.45e-4;  % natural energy spread
alpha_c = 8.1e-5;  % momentum compaction factor
C       = 480;    % circumference in m
h       = 800;        % harmonic number
I0      = 290e-3;     % beam current in A
U0      = 198.8e3;     % energy loss per turn in eV
E0      = 2.2e9;      % beam energy in eV
V_mc    = 0.85e6;   % MC voltage in V
n_hc    = 3;          % harmonic number of HHC
Q_hc    = 5e5;      % quality factor of HHC
R_hc    = Q_hc*90;% shunt impedance of HHC
% fre_shift = 4300;   % detuning of HHC
fre_shift=detune_HC_calc(I0,n_hc,C,h,U0,V_mc,R_hc,Q_hc); % near-optimum lengthening condition
```

The detuning of HHC can be set in default by the near-optimum lengthening condition, or directly given a value.

2 Fill pattern.

```
% HALF
pattern = ones(1,h); % complete fill
% pattern=zeros(1,h);pattern(1:720)=1; % long gap fill
```

where 1 means fill, 0 means empty.

3 Charge configuration

```
% charge configuration
% 2% random charge distribution
charge_ratio = ones(1,h).*pattern;
charge_ratio = charge_ratio+randn(1,h)*0.02.*pattern;
charge_ratio = charge_ratio/sum(charge_ratio)*Bun_num;
```

If the last two lines are commented out with “%”, then it corresponds to the uniform charge configuration.

4 Iterative criterion setting

```
%% Iterative criterion setting
err = 1e-12; iteration = 0;  % for density distribution iteration
accuracy=1e-2;den_error = 1; % for synchrotron phase deviation iteration
```

The values of “err” and “accuracy” can be adjusted. For HALF with the case of R/Q 90 Ohm, we can obtain a periodic dynamic solution with setting this two values.

5 Total number of iterations.

编辑器 - D:\Github\MainIterationLoopCode.m

EquilibriumSolution.m | MainIterationLoopCode.m

```
1 while den_error > err && iteration<=1000 % the total number of iterations
2 iteration = iteration + 1;
```

Usually, to observe the periodic dynamic solution, the number of iteration should be larger than 1000.

1 Normal case

Assuming a complete fill with equal charges, for the case of 250 mA, normal results can be obtained, as shown in Figure 1.

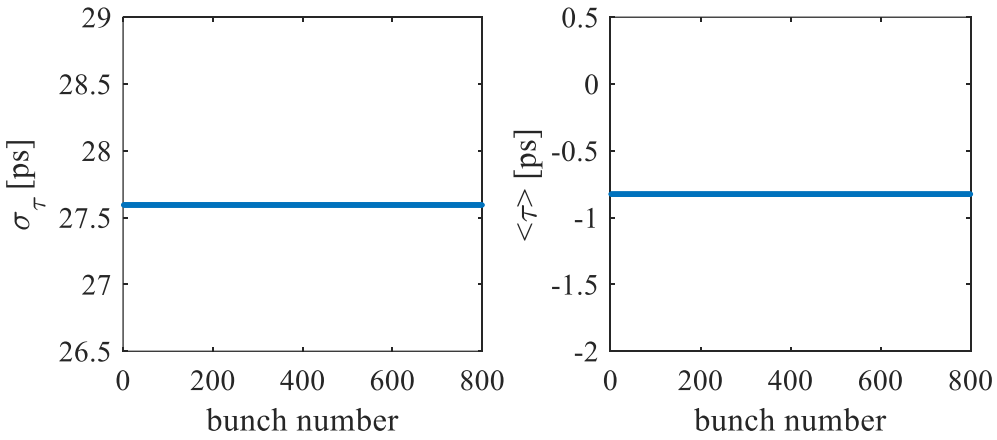

Fig.1 rms bunch length and centroid position vs. bunch number

The whole iterations take 23 seconds.

2 Periodic case

If the beam current was set to 300 mA, then periodic dynamic results can be obtained, as shown in Figure 2 and 3.

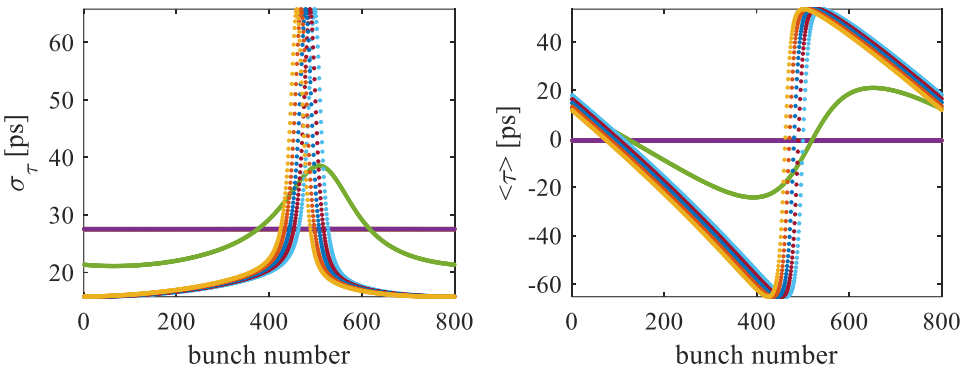

Fig.1 rms bunch length and centroid position vs. bunch number at different iteration number.

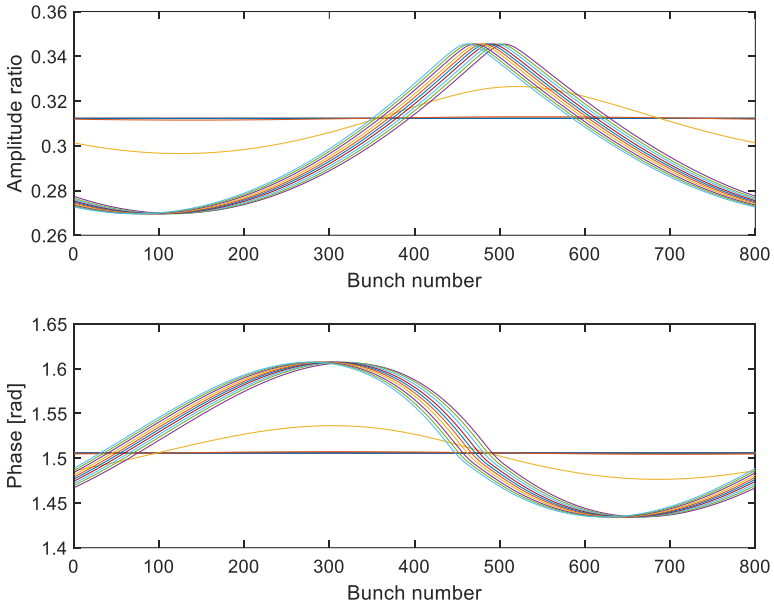

Fig.3 HC voltage vs. bunch number at different iteration number.

The total number of iteration is set to 1000.

This code can successfully give the periodic dynamic solution, which has been verified by the tracking simulation. Enjoy it!