Karlsruhe Institute of Technology

ANKA THZ GROUP

Simulation of Microbunching: Numerical Stability and Optimizations

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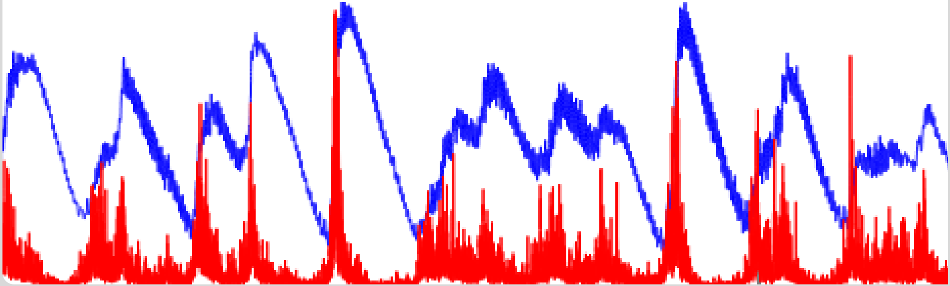
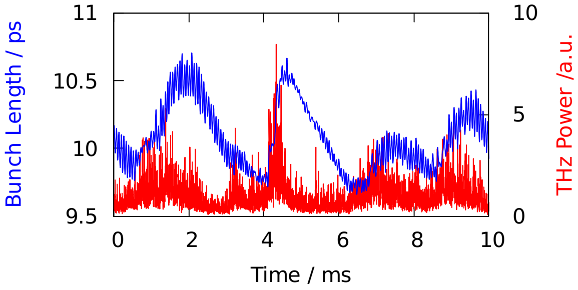


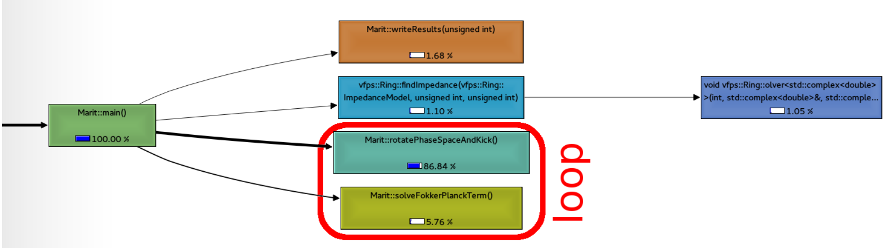
Motivation



- Bunch current $I_b > I_{th}$
- Bunch profile constantly changes
- Coherent radiation in bursts
- Bursting frequencies $f_{lo} < 1\,\mathrm{kHz}$ to $f_{hi} \gg 1\,\mathrm{kHz}$
- Fokker-Planck-Solvers proven to work for $I_b < I_{max} \approx I_{th}$ (and f_{hi})
- Not optimized for numerical long-term ($\mathcal{O}(\mathrm{ms})$) stability
- Tests for numerical stability needed for every single run

Vlasov-Fokker-Planck-Solvers

- Calculate impedance, wake, and initial distribution
- Start time loop:
  - Rotate phase space and apply force (from wake)
  - Apply Fokker-Planck-Term (damping, diffusion)

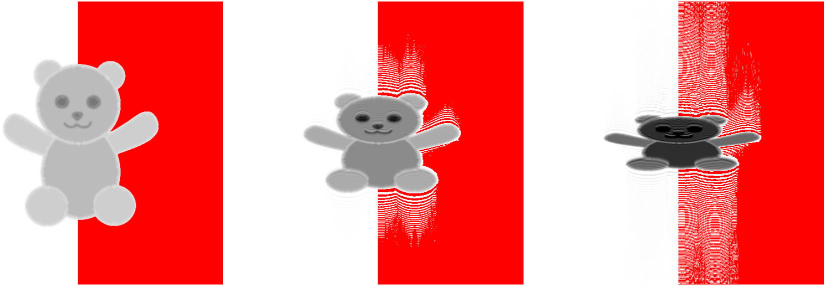


$$\frac{\partial f}{\partial t} + \frac{\partial H}{\partial q}\frac{\partial f}{\partial q} - \frac{\partial H}{\partial q}\frac{\partial f}{\partial p} = 2t_E\frac{\partial}{\partial p}(pf) + D\frac{\partial^2 f}{\partial p^2}$$

Example: Damping

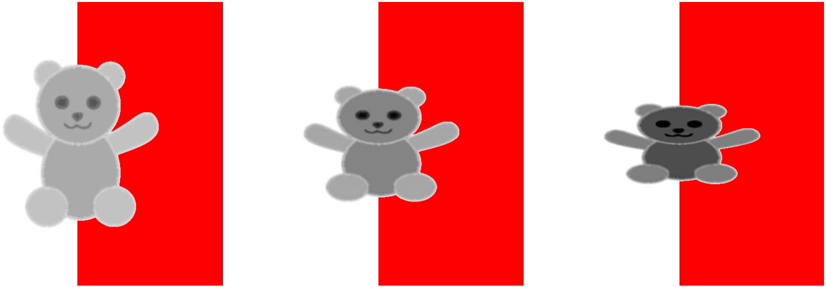
$$\frac{\partial f}{\partial t} + \frac{\partial H}{\partial q}\frac{\partial f}{\partial q} - \frac{\partial H}{\partial q}\frac{\partial f}{\partial p} = 2t_E\frac{\partial}{\partial p}(pf) + D\frac{\partial^2 f}{\partial p^2}$$

Example: Damping



$$\left.\frac{\partial f(x)}{\partial x}\right|_{x=x_0} \approx \frac{f(x_0+\Delta x) - f(x_0-\Delta x)}{2\Delta x} \left(= \left.\frac{\partial P_2(x)}{\partial x}\right|_{x=x_0} \right)$$

Example: Damping



$$\left.\frac{\partial f(x)}{\partial x}\right|_{x=x_0} \approx \frac{-2f(x_0-\Delta x) - 3f(x_0) + 6f(x_0+\Delta x) - f(x_0+2\Delta x)}{6\Delta x}$$

$$\left(= \left.\frac{\partial P_3(x)}{\partial x}\right|_{x=x_0} \right)$$