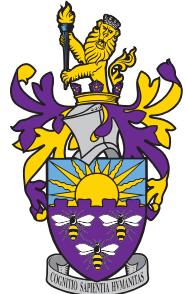


Project: A compact plasma beam dump for next generation particle accelerators.

Supervisor: Dr. Guoxing Xia.

Duration: 24 Weeks, 2018-19.

Location: The University of Manchester,
Cockcroft Accelerator Group,
Manchester, UK.



Week 1

- First meeting with Guoxing: Discussed project outline, necessary background reading and the EPOCH software. Received documents from Guoxing: LFWA PhD thesis [1], PWFA and beam dump papers [2, 3, 4, 5, 6, 7] and EPOCH users manual [8].
- Read theory section in Hanahoe's thesis [7].
- Weekly outline: Background reading to understand the theory of LWFA, PWFA and plasma wakefield deceleration. I will study the beam dump so no laser will feature in my simulations, however good to study LWFA to understand more about PWFA. There are several PIC softwares: QuickPIC, OSIRIS, VLPL3D, Vorpal, EPOCH, XOPIC, OOPIC, LCODE...why use EPOCH?
- Concepts covered:
 - Gessner (2.3-2.4) - **Linear regime:** Response of a cold, non-interacting plasma, with a ultra-relativistic "delta function" particle beam by considering the electron density perturbation n_1 . Compute Green's function for n_1 and then convolve the solution with a 2-D Gaussian beam to get the plasma's response of a non-point-like beam, (2.18 Gessner). I could produce 2D plot n_1/n_0 to show this response.
 - Derive wave equations for \mathbf{E} and \mathbf{B} fields in the plasma following the density perturbation.
 - Derive longitudinal and transverse E -fields for the ultra-relativistic delta function driving bunch, then convolve with extended Gaussian beam.
 - **Non-linear regime:** Derive accelerating and transverse fields in the blow-out regime (Gessner 2.7).
- I read Wu et al. - *Collective deceleration: Toward a compact beam dump*[5] . No yet summarised the theory section in this paper.
- Questions:
 - Should I look at LWFA theory as well, even though we won't have lasers present in the beam dump? Actually, the active scheme proposed by Bonatto et al. is laser-driven so I should look at LWFA as well, right?
 - Should I also look at positron beam dumping if I am to look at the ILC beam dump?
- Concepts to look up:
 - Bump-on-tail instability.
 - Landau damping
 - Plasma beatatron-wavelength
 - Look up current beam dumps for e-colliders and tabletop LWFAs .

Linear regime: Perturbation due to beam $n(r, \xi) \rightarrow n(r, \xi) + \tilde{n}(r, \xi)$, use Maxwell's equations and continuity equation.

- *Density:*

$$-\frac{1}{k_p^2} \left(\frac{\partial^2}{\partial \xi^2} + k_p^2 \right) \tilde{n}(r, \xi) = n_b(r, \xi) , \quad \tilde{n}(r, \xi < 0) = 0 \quad (1)$$

$$\mathcal{L}_\xi \tilde{n}(r, \xi) = n_b(r, \xi) \Rightarrow \mathcal{L}_\xi G(\xi, \xi') = \delta(\xi) \quad (2)$$

$$G(\xi, \xi') = \begin{cases} 0 & , -\infty < \xi < 0 \\ A \sin((k_p \xi) + B \cos(k_p \xi)) & , 0 < \xi < \infty \end{cases} \quad (3)$$

where the Green's function obeys the same b.c as the density perturbation, i.e it is continuous across the boundary with a discontinuous derivative across the boundary. Integrate across discontinuity at $\xi = 0$

$$\lim_{\epsilon \rightarrow 0} \int_{-\epsilon}^{\epsilon} \mathcal{L}_\xi G(\xi, \xi') d\xi = \lim_{\epsilon \rightarrow 0} \int_{-\epsilon}^{\epsilon} \delta(\xi) d\xi = 1 \quad \Rightarrow \quad \lim_{\epsilon \rightarrow 0} \left[-\frac{1}{k_p^2} \frac{\partial G}{\partial \xi} \right]_{-\epsilon}^{\epsilon} = 1 \quad (4)$$

$$G(\xi, \xi') = -k_p \sin(k_p \xi) \Theta(\xi) \quad \Rightarrow \quad \tilde{n}(r, \xi) = \int_{-\infty}^{\infty} G(\xi, \xi') n_b(r, \xi') d\xi' \quad (5)$$

Week 2

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