# High quality beam produced by tightly focused laser driven wake-field accelerators

Original authors of paper: Jia Wang, Ming Zeng, Dazhang Li, Xiaoning Wang, and Jie Gao
e-print: https://arxiv.org/abs/2304.10730 (2023)
Notebook: Óscar Amaro, September 2023 @ GoLP-EPP

## Equation 5: bubble radius

In[∘]:=
```
Clear[Fpr, F, α, Ω, γavg, ωp, k, c, κ2, res, r, W, W0]
α = Ω γavg;
ωp = k c;
κ2 = ωp ^ 2 me / α;
res = Solve[-κ2 r == (me c ^ 2 a0 ^ 2 W0 ^ 2 r)/(W ^ 4 γavg) Exp[-2 r ^ 2 / W ^ 2], r][[3, 1, 2]]
```

Solve: Inverse functions are being used by Solve, so some solutions may not be found; use Reduce for complete solution information.

Out[∘]=
$$\frac{i\, W \sqrt{\mathrm{Log}\left[-\frac{k^2 W^4}{a0^2\, W0^2\, \Omega}\right]}}{\sqrt{2}}$$

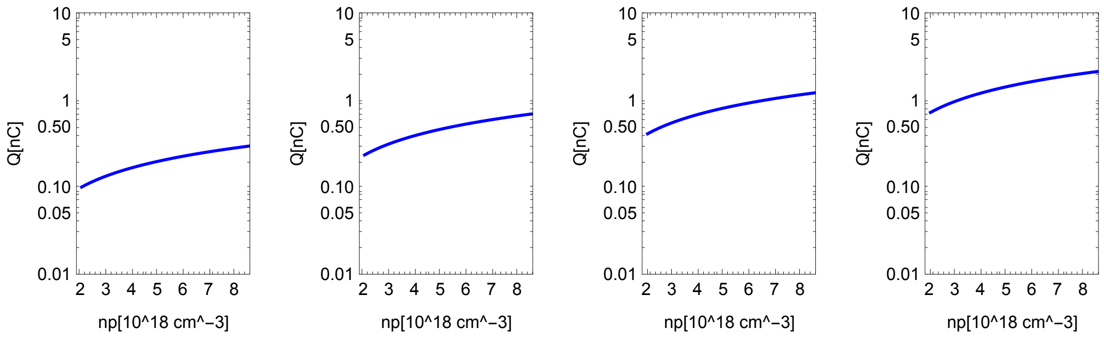
# Figure 7 and 8

In[•]:=
```
Clear[Linj, zRe, Ω, a0, kp, W0, Γ, Q, C, λ, kp, ωp, c, e, ϵ0, me, npcm, a0lst, npcmlst]

me = 9.1 × 10^-31;(*[Kg]*)
c = 3 × 10^8;(*[m/s]*)
ωp = Sqrt[(np e^2)/(me ϵ0)];(*[1/s]*)
kp = ωp / c;(*[1/m]*)
e = 1.6 × 10^-19;(*[C]*)
ϵ0 = 8.854 × 10^-12;(*[F/m]*)

λ = 0.8;(*[μm] see §IV *)
Ω = 2;(* see §IV *)
zRe = π W0^2 Γ^2 / λ; (* after eq 2 *)
Linj = zRe Sqrt[Exp[-1] (√Ω a0)/(Γ^2 kp W0) - 1];(*eq 7*)
Γ = (-np)/20.16 + a0/100 - W0/46.42 + 1.029;(*eq 9 *)
Q = C Linj np a0(*eq 8 *)

C = 8 × 10^-8;(* this value, although not expllicit in the text,
seems to reproduce results of figures 7 and 8 *)
np = 10^-12 npcm;

(* Figure 7 *)
a0lst = {4.9, 8.45, 12, 16.97};
GraphicsRow[
 Table[LogPlot[10^9 Q /. {W0 → 5, a0 → a0lst⟦i⟧}, {npcm, 2, 8.5}, AspectRatio → 1.5,
   ImageSize → 150, Frame → True, PlotRange → {10^-2, 10^1}, PlotStyle → Blue,
   FrameLabel → {"np[10^18 cm^-3]", "Q[nC]"}], {i, 1, 4}]]

npcmlst = {2, 4, 6, 8};
GraphicsRow[Table[LogPlot[10^9 Q /. {W0 → 5, npcm → npcmlst⟦i⟧}, {a0, 5, 35},
   AspectRatio → 1.5, ImageSize → 150, Frame → True, PlotRange → {10^-2, 10^1},
   PlotStyle → Blue, FrameLabel → {"a0", "Q[nC]"}], {i, 1, 4}]]

(* Figure 8 *)
a0lst = {12, 10, 8, 6};
npcmlst = {2, 4, 6};
GraphicsGrid[Table[Plot[10^9 Q /. {a0 → a0lst⟦i⟧, npcm → npcmlst⟦j⟧}, {W0, 3, 9},
   AspectRatio → 1, ImageSize → 150, Frame → True, PlotRange → {0, 2},
   PlotStyle → Blue, FrameLabel → {"a0", "Q[nC]"}], {j, 1, 3}, {i, 1, 4}]
]
```

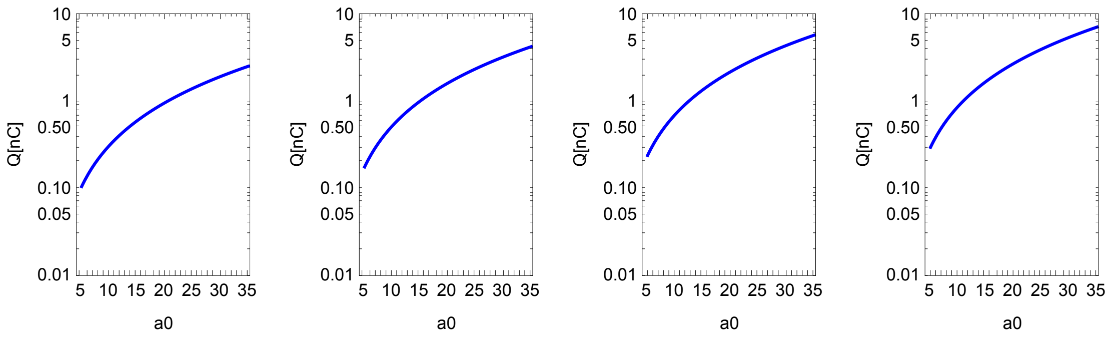
Out[•]=

$$3.92699\times10^{-12}\,\mathtt{a0}\,\mathtt{npcm}\sqrt{-1+\frac{2.76893\times10^{12}\,\mathtt{a0}}{\sqrt{\mathtt{npcm}}\left(1.029+\frac{\mathtt{a0}}{100}-4.96032\times10^{-14}\,\mathtt{npcm}-0.0215424\,\mathtt{W0}\right)^{2}\mathtt{W0}}}\left(1.029+\frac{\mathtt{a0}}{100}-4.96032\times10^{-14}\,\mathtt{npcm}-0.0215424\,\mathtt{W0}\right)^{2}\mathtt{W0}^{2}\,C$$

Out[•]=




Out[•]=



Out[∘]=