Classical and Quantum Description of Plasma and Radiation in Strong Fields , PhD Thesis

Fabien Niel et al 2021 Springer Theses https://link.springer.com/-book/10.1007/978-3-030-73547-0

Notebook: Óscar Amaro, September 2023 @ GoLP-EPP

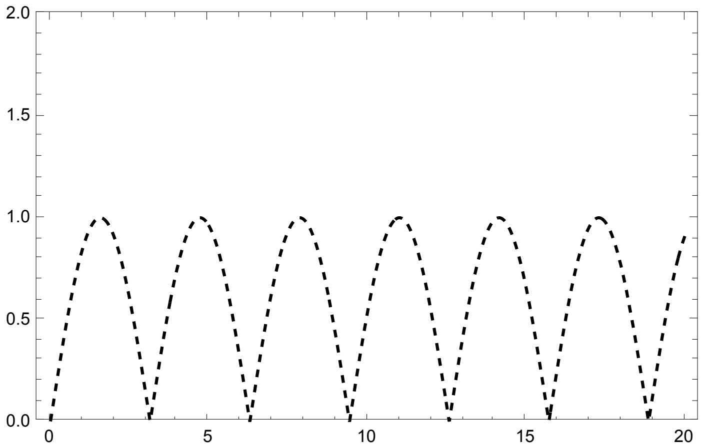
Introduction

Some calculations.

Figure 8.1

```
Clear[a0, γ, χ, βy, βz, t]
a0 = 500;

(*Attention: mistake in the Thesis in γ expression ? *)
γ = Sqrt[1 + a0^2 Sin[t]^2];
Plot[γ / a0, {t, 0, 20}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False, PlotRange → {0, +2}]

(* ω0=1eV?? *)
χ = 1 / (0.511 × 10^6) a0 Sqrt[1 + 4 a0^2 Sin[t / 2]^4];
Plot[χ, {t, 0, 20}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False, PlotRange → {0, +1.5}]

βy = a0 Sin[t] / Sqrt[1 + 4 a0^2 Sin[t / 2]^2];
Plot[βy, {t, 0, 20}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False, PlotRange → {-1, +1}]

βz = a0 (1 - Cos[t]) / Sqrt[1 + 4 a0^2 Sin[t / 2]^2];
Plot[βz, {t, 0, 20}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False, PlotRange → {-1, +1}]
```

Out[∘]=



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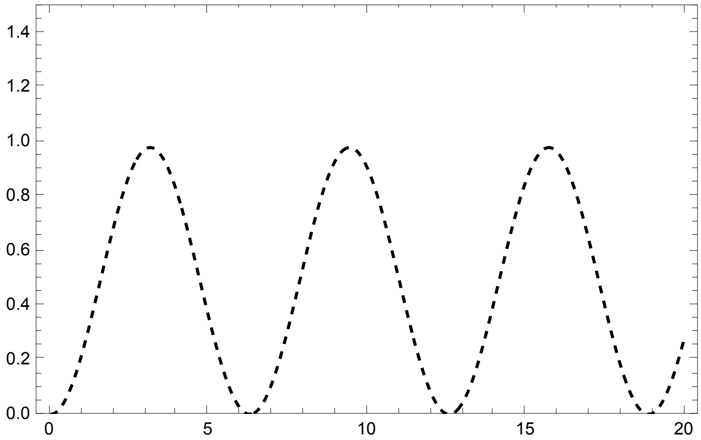

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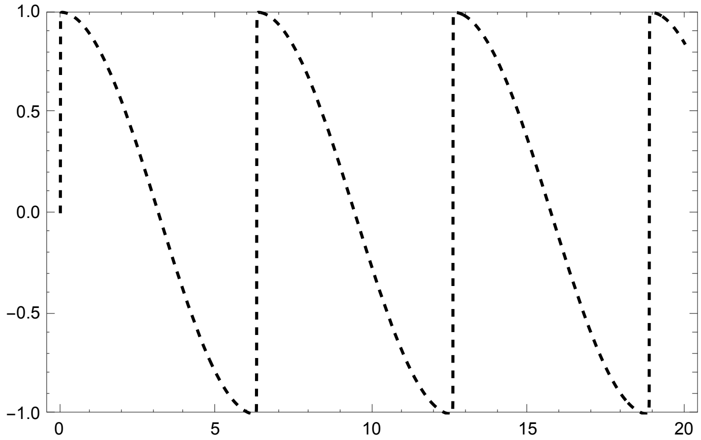

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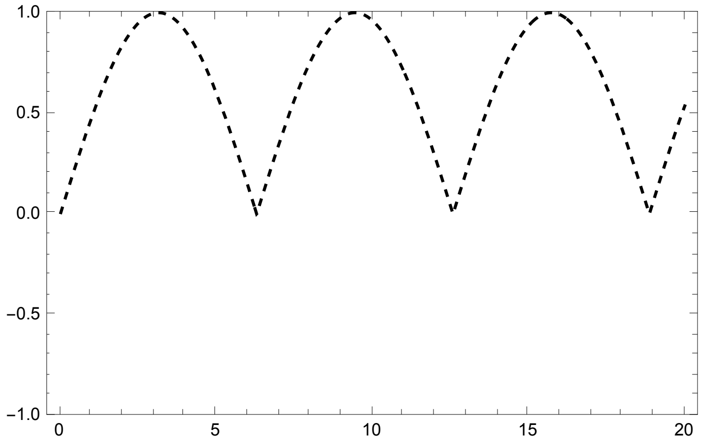


Figure 8.3 Asymptotic expressions

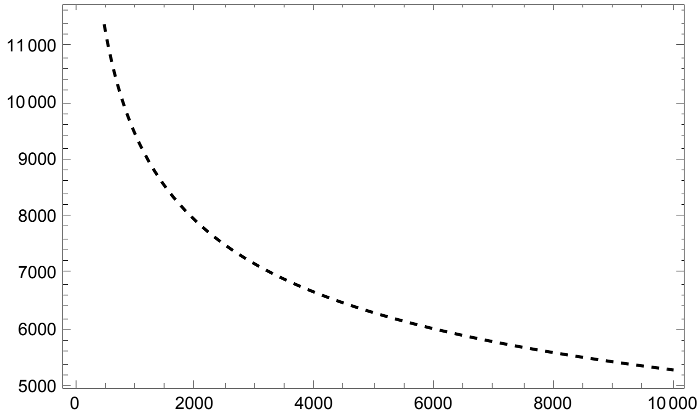
In[∘]:=
```
Clear[a0, γ, χ, βy, βz, t, A, α]
aS = 400 000;
α = 1 / 137;
A = 2 / 3 α;
γas = Sqrt[aS] ( a0 / (0.56 A)) ^0.75 ;
βEas = Sqrt[a0 - Sqrt[a0] aS / (0.56 A) ^1.5];
χas = a0^1.5 / (0.56 A) ^0.75;

Plot[γas / a0, {a0, 0, 10 000}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False] (*PlotRange→{0,+1}*)

Plot[χas, {a0, 0, 10 000}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False] (*PlotRange→{0,+30}*)

Plot[βEas, {a0, 0, 10 000}, PlotStyle → Directive[Black, Dashed],
 Frame → True, Axes → False] (*PlotRange→{0,+1}*)
```

Out[∘]=



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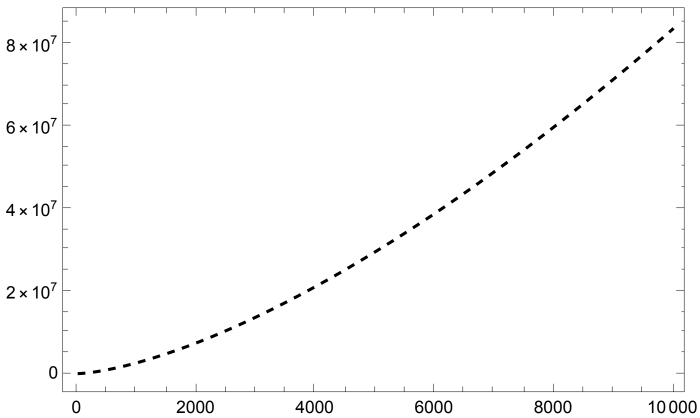

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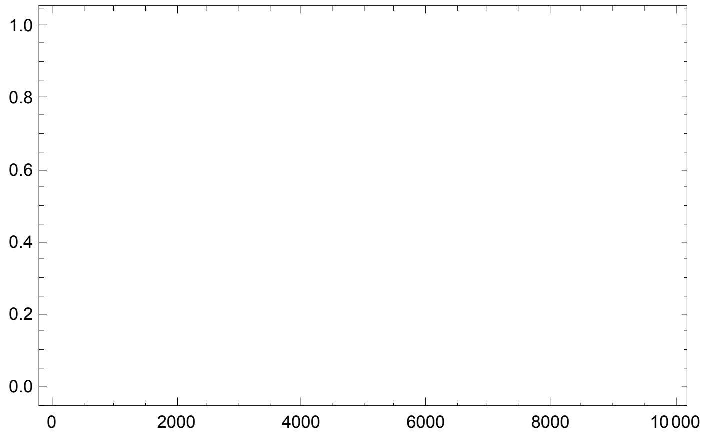


Figure 8.4

We try to reproduce figure 8.4 from Fabien Niel’s PhD thesis. The text in the textbook might have some omissions and changes in notation. We are able to reproduce the S type curve, but the asymptotic value is not the one in the text.

Also, it’s possible to derive the σe∞ for χ<<1 using the χ<<1 expressions for S and h $\sigma \sim 0.8 \sqrt{\frac{\chi}{2-3\chi}}$

In[∘]:=
```
Clear[α, τ, χ, g, h, S, dh, dS, dχ]
Clear[m, c, re]
```

$$g[\chi\_?\text{NumericQ}] := g[\chi] = \frac{9\times\sqrt{3}}{8\,\pi}\ \text{NIntegrate}\left[\frac{2\,\nu\text{^}2\,\text{BesselK}[5/3,\nu]}{(2+3\,\nu\,\chi)\text{^}2}+\frac{4\,\nu\,(3\,\nu\,\chi)\text{^}2}{(2+3\,\nu\,\chi)\text{^}4}\,\text{BesselK}[2/3,\nu],\{\nu,0,\infty\}\right]$$

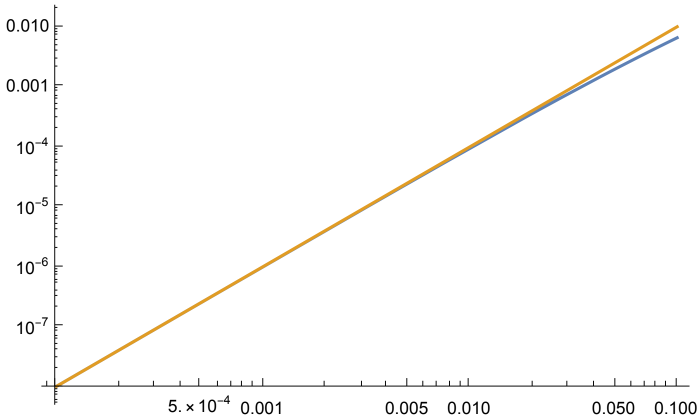
$$S[\chi\_?\text{NumericQ}] := S[\chi] = \chi\text{^}2\,g[\chi]$$

$$h[\chi\_?\text{NumericQ}] := h[\chi] = \frac{9\times\sqrt{3}}{4\,\pi}\ \text{NIntegrate}\left[\frac{2\,\chi\text{^}3\,\nu\text{^}3\,\text{BesselK}[5/3,\nu]}{(2+3\,\nu\,\chi)\text{^}3}+\frac{54\,\chi\text{^}5\,\nu\text{^}4}{(2+3\,\nu\,\chi)\text{^}5}\,\text{BesselK}[2/3,\nu],\{\nu,0,\infty\}\right]$$

```
LogLogPlot[{S[χ], χ^2}, {χ, 10^-4, 10^-1}, PlotPoints → 2]

LogLogPlot[{h[χ], 2 χ^3}, {χ, 10^-4, 10^-1}, PlotPoints → 2]
```

Out[∘]=



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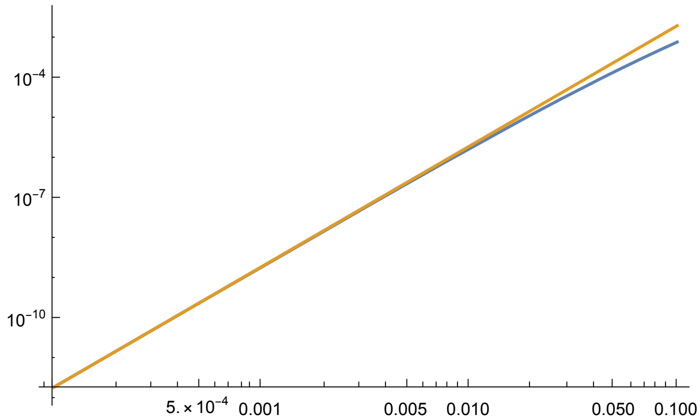

```
Clear[α, τ, χ, g, h, S, dh, dS, dχ, tab, tabapp, σapp, σeinf]
Clear[m, c, re]
```

$$g[\chi\_] := \frac{9 \times \sqrt{3}}{8\pi} \text{NIntegrate}\left[\frac{2\,\nu\text{^}2\,\text{BesselK}[5/3,\nu]}{(2+3\,\nu\,\chi)\text{^}2} + \frac{4\,\nu\,(3\,\nu\,\chi)\text{^}2}{(2+3\,\nu\,\chi)\text{^}4}\,\text{BesselK}[2/3,\nu],\ \{\nu, 0, \infty\}\right]$$

$$S[\chi\_] := \chi\text{^}2\,g[\chi]$$

$$h[\chi\_] := \frac{9 \times \sqrt{3}}{4\pi} \text{NIntegrate}\left[\frac{2\,\chi\text{^}3\,\nu\text{^}3\,\text{BesselK}[5/3,\nu]}{(2+3\,\nu\,\chi)\text{^}3} + \frac{54\,\chi\text{^}5\,\nu\text{^}4}{(2+3\,\nu\,\chi)\text{^}5}\,\text{BesselK}[2/3,\nu],\ \{\nu, 0, \infty\}\right]$$

$$d\chi = 0.0000001;$$

$$dh[x\_] := \frac{(h[x+d\chi] - h[x-d\chi])}{2\,d\chi}$$

$$dS[x\_] := \frac{(S[x+d\chi] - S[x-d\chi])}{2\,d\chi}$$

```
(*equation (8.25) of Fabien Niel's thesis *)
```

$$\sigma einf[\chi avg\_] := \text{Sqrt}\left[\frac{h[\chi avg]}{1.55\,\chi avg\,(2\,dS[\chi avg] - dh[\chi avg])}\right] \text{ // Quiet}$$

$$\sigma app[\chi\_] := 0.8032193289024989\text{`}\,\sqrt{\frac{\chi}{2-3\,\chi}}\ (*\text{Sqrt}\left[\frac{2\chi\text{^}3}{1.55\ \chi(2\ 2\chi-6\chi\text{^}2)}\right]*)$$

In[∘]:=
```
tab = ParallelTable[{10^χ, σeinf[10^χ]}, {χ, -6, 4.5, 0.5}];
tabapp = ParallelTable[{10^χ, σapp[10^χ]}, {χ, -6, 4.5, 0.5}];
```

In[∘]:=
```
ListLogLinearPlot[{tab, tabapp}, Joined → {True, False}]
```

Out[∘]=