On-shot diagnostic of electron beam-laser pulse interaction based on stochastic quantum radiation reaction

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Introduction

Contrary to CRR or MCRR, QRR through stochasticity will induce an asymmetry in the momentum space (x,y) orthogonal to propagation (z), with a visible increase along polarization (x), while in the remaining direction the divergence does not change significantly.

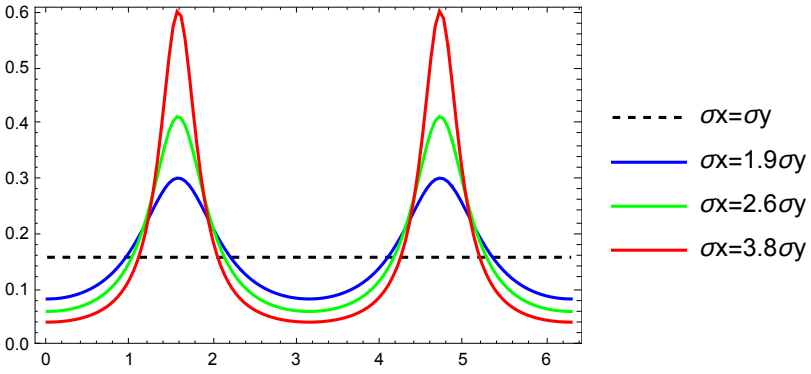
Figure 2

```
In[•]:= Clear[m, px, py, σx, σy, p, θ, dNdθ]
        n = Exp[-0.5 (px^2 / σx^2 + py^2 / σy^2)];
        px = p Sin[θ];
        py = p Cos[θ];

        Integrate[p n, {p, 0, ∞}] // Normal
```

$$\text{Out}[\bullet]= \frac{1}{\frac{1.\,\text{Cos}[\theta]^2}{\sigma y^2}+\frac{1.\,\text{Sin}[\theta]^2}{\sigma x^2}}$$

In[34]:=
```
dNdθ[θ_, σx_, σy_] := 1 / (Cos[θ]^2/σy^2 + Sin[θ]^2/σx^2)

(* approximate choices of σy/σx to match Figure 2 *)
dNdθnorm[θ_, σx_, σy_] :=
 dNdθ[θ, σx, σy] / NIntegrate[dNdθ[θθ, σx, σy], {θθ, 0, 2 π}]
Plot[{dNdθnorm[θ, 1, 1], dNdθnorm[θ, 1.9, 1], dNdθnorm[θ, 2.6, 1],
  dNdθnorm[θ, 3.8, 1]}, {θ, 0, 2 π}, AxesLabel → {"θ", "dN/dθ"},
 ImageSize → 300, PlotLegends → {"σx=σy", "σx=1.9σy", "σx=2.6σy", "σx=3.8σy"},
 PlotStyle → {{Black, Dashed}, Blue, Green, Red},
 PlotPoints → 3, Frame → True, PlotRange → {0, 0.61}]
```

Out[36]=



In[•]:=
```
(* As you would expect, peaks happen at π/2 and 3π/2 for σx>σy *)
dθ = D[1 / (Cos[θ]^2/σy^2 + Sin[θ]^2/σx^2), θ];

Solve[dθ == 0, θ]
```

Out[•]=
$$\left\{\left\{\theta \to 2\pi c_1 \text{ if } c_1 \in \mathbb{Z}\right\}, \left\{\theta \to -\frac{\pi}{2} + 2\pi c_1 \text{ if } c_1 \in \mathbb{Z}\right\},\right.$$
$$\left.\left\{\theta \to \frac{\pi}{2} + 2\pi c_1 \text{ if } c_1 \in \mathbb{Z}\right\}, \left\{\theta \to \pi + 2\pi c_1 \text{ if } c_1 \in \mathbb{Z}\right\}\right\}$$

In[•]:=
```
(*sqrt of max and min gives δ *)
Refine[Sqrt[dNdθ[π / 2, σx, σy] / dNdθ[π, σx, σy]], {σx > 0, σy > 0}]
```

Out[•]=
$$\frac{\sigma x}{\sigma y}$$

In[•]:=
```
(* taking data from Fig2 with Webplot
 digitizer allows us to compute the asymmetry *)
max = {0.2997, 0.42199, 0.58887};
min = {0.09752, 0.07331, 0.052299};
δ = Sqrt[max / min]
Asym = (δ - 1) / (δ + 1)
```

Out[•]= {1.75306, 2.39922, 3.35554}

Out[•]= {0.273535, 0.411629, 0.540815}