```
In[1]:= (*Math for Quantum Properties of Light*)

In[2]:= << "Miscellaneous`PhysicalConstants`"

        (* it now knows the main constants,
         but uses full names of units, e.g. Meter instead of m,
         etc. To make things more standard we defined a list replacements*)

        rep = {Meter → m, Second → s, Joule → J,
           Kilogram → kg, Jpoule};

In[9]:= c = SpeedOfLight /. rep
```

Out[9]= $\frac{299792458\ \mathrm{m}}{\mathrm{s}}$

```
In[12]:= h = PlanckConstant /. rep
```

Out[12]= $6.62607\times10^{-34}\ \mathrm{J\ s}$

```
In[13]:= hbar = PlanckConstantReduced /. rep
```

Out[13]= $1.05457\times10^{-34}\ \mathrm{J\ s}$

```
In[16]:= mel = ElectronMass /. rep
```

Out[16]= $9.10938\times10^{-31}\ \mathrm{kg}$

```
In[17]:= eV = (J ElectronCharge / Coulomb) /. rep
```

Out[17]= $1.60218\times10^{-19}\ \mathrm{J}$

```
In[18]:= lcompt = h / (mel c)
```

Out[18]= $\frac{2.42631\times10^{-12}\ \mathrm{J\ s^2}}{\mathrm{kg\ m}}$

```
In[19]:= J = kg m^2 / s^2
```

Out[19]= $\frac{\mathrm{kg\ m^2}}{\mathrm{s^2}}$

```
In[20]:= lcompt
```

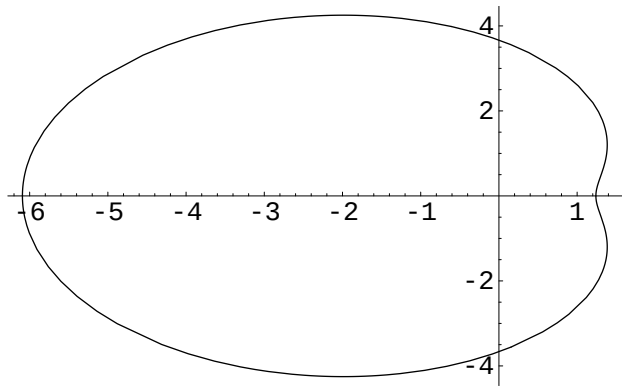
Out[20]= $2.42631\times10^{-12}\ \mathrm{m}$

```
In[21]:= lamb[en_] := c h / en

In[26]:= λ[en_, ϕ_] := lamb[en] + lcompt (1 - Cos[ϕ])

In[23]:= plo[en_] := ParametricPlot[{λ[en, ϕ] Cos[ϕ], λ[en, ϕ] Sin[ϕ]} /. m → 10^12, {ϕ, 0, 2 Pi}]
```

In[28]:= **plo[10^6 eV]**

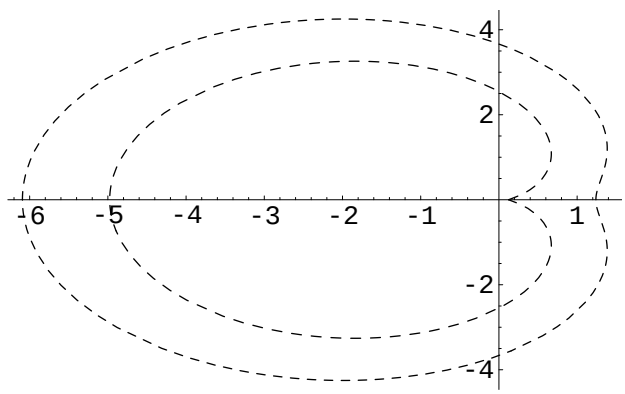


Out[28]= - Graphics -

In[36]:= **plo[en_] := ParametricPlot[{λ[en, ϕ] Cos[ϕ], λ[en, ϕ] Sin[ϕ]} /. m → 10^12, {ϕ, 0, 2 Pi}, PlotStyle → Dashing[{.001 * Log[en / eV]}], DisplayFunction → Identity]**

In[37]:=

In[38]:= **Show[plo[10^6 eV], plo[10^7 eV], DisplayFunction → $DisplayFunction]**



Out[38]= - Graphics -