

SED

```

e := 4.8 * 10-10          (*StatCoulomb*)
Bcgs := 7 * 10-6          (*Gauss=cm-1/2 g1/2 s-1*)
Bsi := 7 * 10-10         (*Tesla*)
mc2 := 511 000            (*eV*)
m := 9.1 * 10-28          (*g*)
c := 3 * 1010            (*cm/s*)
h := 6.63 * 10-27         (*ergios s*)
pc2cm := 3.0857 * 1018
Rout := 10 * pc2cm (*cm*)
Rin := 7.5 * pc2cm (*cm*)
Dsrn := 15 000 * pc2cm
f2L := 4 * π * Dsrn2 (*factor para pasar de flujo a luminosidad en tabla *)
V :=  $\frac{4}{3} * \pi * (Rout^3 - Rin^3)$  (*cm3*)
fvol := 0.16
α := 1.9
A := 2.36 * 10-12 (*en cgs*)
CC := 1.85 (*viene de la aproximacion bessell*)
Eemaxev := 3.176 * 1013 (*eV*)
Eeminev := 1 * 106 (*= $\frac{E_{ph}}{E_c}$  eV*)
Eemaxerg := 3.176 * 1013 * 1.602 * 10-12 (*ergios*)
Eeminerg := 1.61 * 10-6 (*ergios*)
erg2ev := 1 / ev2erg
ev2erg := 1.602 * 10-12
Ae := 0.0975 (*ev0.9 cm-3*)
Eemax := 3.176 * 1013 (*eV*)
β :=  $\frac{1}{137}$ 
re := 2.8179 * 10-13 (*cm*)
n := 0.011 (*cm-3*)
x := 0.17
Eerep := 511 000 (*eV*)
Eemin := 1 * 106 (*eV*) (*1MeV*)
k := 8.61 * 10-5; (*eV/kelvin*)
T := 2.7 (*Kelvin*)
hev := 4.13 * 10-15 (*eV s*)
σT := 0.66 * 10-24 (*cm2*)
Eprep := 938 257 * 103 (*eV*);
Eπrep := 139 600 * 103 (*eV*);
Epmax := 2.5553 * 1013 (*eV*);
Ap := 42.5397818502 (*ev0.9 cm-3*)

(*Sincro*)

```

$$PP[Eph_ , Ee_] := \frac{\sqrt{3} * \pi * e^3 * Bcgs}{h * m * c^2} * CC * \left(\frac{Eph}{\frac{3}{4 \pi} * \frac{e * h * Bcgs}{m * c} * \left(\frac{Ee}{m * c^2} \right)^2} \right)^{\frac{1}{3}} * e^{-\left(\frac{3}{4 \pi} * \frac{e * h * Bcgs}{m * c} * \left(\frac{Ee}{m * c^2} \right)^2 \right)}$$

$$NSinc[Ee_] := A * Ee^{-\alpha} * e^{\frac{-Ee}{Eemaxerg}}$$

$$P[Eph_] :=$$

$$NIntegrate[PP[Eph, Ee] * NSinc[Ee], \{Ee, Eeminerg, Eemaxerg\}, AccuracyGoal \rightarrow 12]$$

$$L[Eph_] := Eph * P[Eph] * V * fvol$$

(*Brems*)

$$\sigma[E\gamma_ , Ee_] := \frac{4 * \beta * re^2}{E\gamma} * \phi[E\gamma, Ee] * ev2erg (*cm^2 eV^{-1}*)$$

$$\phi[E\gamma_ , Ee_] := \left(1 + \left(1 - \frac{E\gamma}{Ee} \right)^2 - \frac{2}{3} * \left(1 - \frac{E\gamma}{Ee} \right) \right) * \text{Log}[191] + \frac{1}{9} * \left(1 - \frac{E\gamma}{Ee} \right)$$

$$I1[Ee_] := \frac{C}{4 \pi} * Ae * Ee^{-\alpha} * e^{\frac{-Ee}{Eemax}}$$

(*IC*)

$$\epsilon_{ph}[Eph_] := \frac{Eph}{Eerep}$$

$$\epsilon_{\gamma}[E\gamma_] := \frac{E\gamma}{Eerep}$$

$$\gamma[Ee_] := \frac{Ee}{Eerep}$$

$$x[Ee_ , Eph_ , E\gamma_] := \frac{\epsilon_{\gamma}[E\gamma]}{4 \epsilon_{ph}[Eph] \gamma[Ee]^2 \left(1 - \frac{\epsilon_{\gamma}[E\gamma]}{\gamma[Ee]} \right)}$$

$$P[Ee_ , Eph_ , E\gamma_] :=$$

$$\text{HeavisideTheta}[1 - x[Ee, Eph, E\gamma]] \text{HeavisideTheta}\left[x[Ee, Eph, E\gamma] - \frac{1}{4 \gamma[Ee]^2}\right]$$

$$f[Ee_ , E\gamma_ , Eph_] := \left(2 x[Ee, Eph, E\gamma] \text{Log}[x[Ee, Eph, E\gamma]] + x[Ee, Eph, E\gamma] + 1 - 2 x[Ee, Eph, E\gamma]^2 + \left((4 \epsilon_{ph}[Eph] \gamma[Ee] x[Ee, Eph, E\gamma])^2 (1 - x[Ee, Eph, E\gamma]) \right) / \left(2 (1 + 4 \epsilon_{ph}[Eph] \gamma[Ee] x[Ee, Eph, E\gamma]) \right) \right) P[Ee, Eph, E\gamma]$$

$$\sigma_{IC}[Ee_ , E\gamma_ , Eph_] := \frac{3 \sigma T}{4 * Eerep * \epsilon_{ph}[Eph] \gamma[Ee]^2} f[Ee, E\gamma, Eph]$$

$$Iic[Ee_] := Ae * Ee^{-\alpha} * e^{\frac{-Ee}{Eemax}}$$

$$nBB[Eph_] := \frac{8 * \pi}{(h * c)^3} * Eph^2 \left(e^{\frac{Eph}{k * T}} - 1 \right)^{-1} * \text{erg2ev}$$

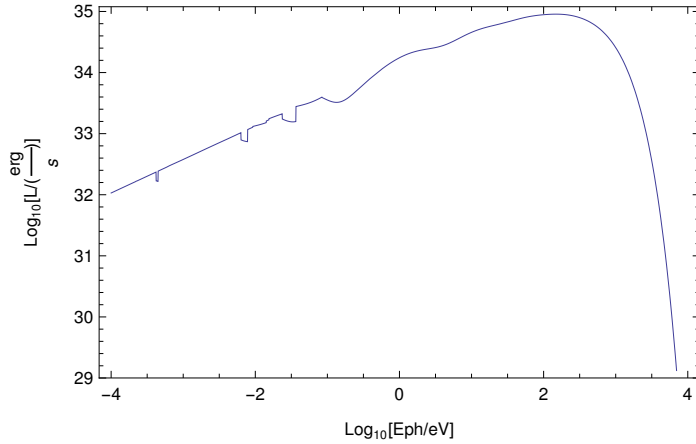
$$\text{Integral1}[E\gamma_ , Ee_] := NIntegrate[nBB[Eph] * \sigma_{IC}[Ee, E\gamma, Eph], \{Eph, 0, 100 * k * T\}]$$

$$\text{Integral2}[E\gamma_] := NIntegrate[\text{Integral1}[E\gamma, Ee] * Iic[Ee], \{Ee, Eemin, 10 * Eemax\}]$$

$$\text{luminosidadIC}[E\gamma_] := E\gamma^2 * fvol * V * \frac{C}{4 \pi} * \text{Integral2}[E\gamma]$$

Sincrotron

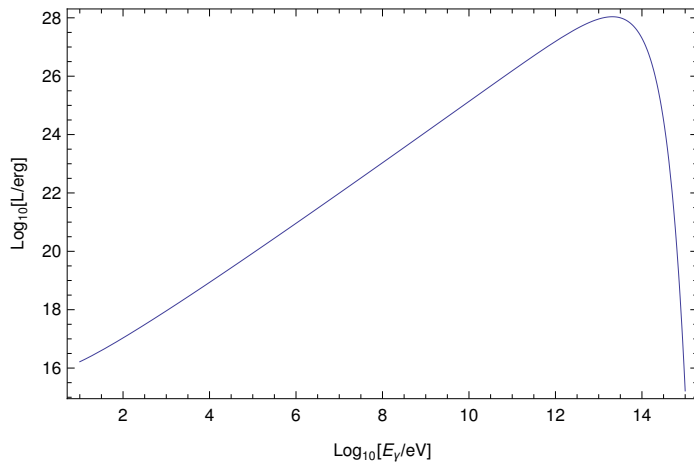
```
Plot[Log[10, L[10^(Eph) / erg2ev]], {Eph, Log[10, 10^-4], Log[10, 10^4]},
  Axes → False, Frame → True, FrameLabel → {"Log10[Eph/eV]", "Log10[L/( $\frac{\text{erg}}{\text{s}}$ )]"}]
```



Bremsstrahlung

```
Plot[Log10[(10^Eγ)^2 * V * fvol *
  NIntegrate[n * σ[Eγ, Ee] * I1[Ee], {Ee, 10^Eγ, ∞}, MaxRecursion → 15] * ev2erg],
  {Eγ, Log10[10^1], Log10[10^15]}, Axes → False, Frame → True,
  FrameLabel → {"Log10[Eγ/eV]", "Log10[L/erg]"}]
```

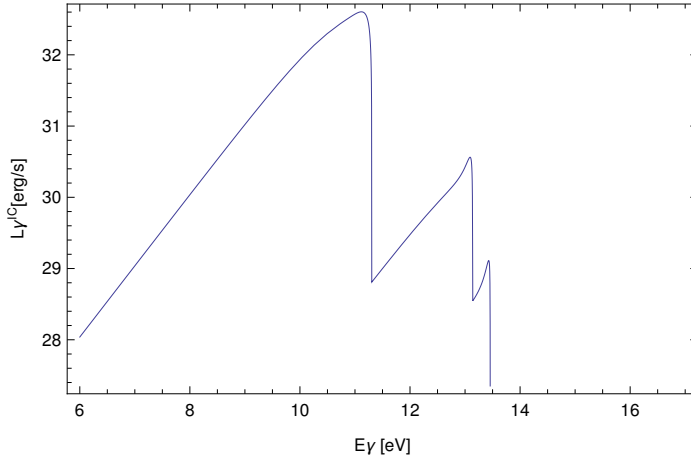
Bremsstrahlung



Inverse Compton

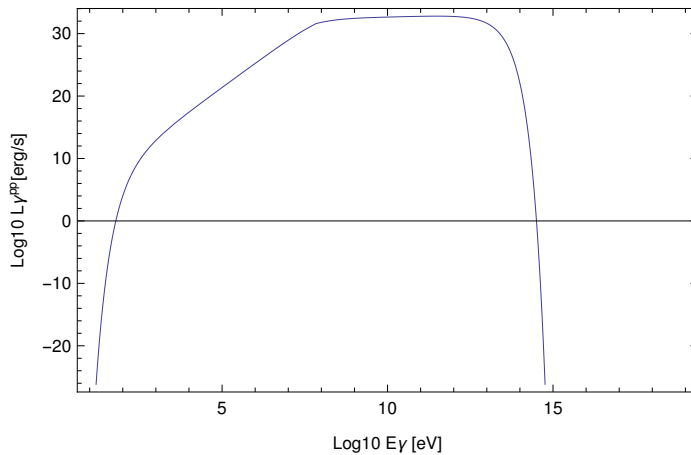
```
Plot[Log[10, luminosidadIC[10^Eγ] / erg2ev], {Eγ, -5.5, 15}, PlotPoints → 10,
  Frame → True, FrameLabel → {"Log Eγ [eV]", "Log LγIC [erg/s]"}, Axes → False]
```

Compton Inverse



Proton Proton

```
Plot[Log[10, (10^Eγ)^2 * fvol * V *  $\frac{2 * c * n}{\kappa}$  *
  Ap * 10^-27 NIntegrate[ $\frac{1}{\sqrt{E\pi^2 - E\pi_{rep}^2}}$  (Eprep +  $\frac{E\pi}{\kappa}$ )^-α * e^- $\frac{(E_{prep} + \frac{E\pi}{\kappa})}{E_{pmax}}$  *
    (34.3 + 1.88 * Log[(Eprep +  $\frac{E\pi}{\kappa}$ ) * 10^12] + 0.25 * Log[(Eprep +  $\frac{E\pi}{\kappa}$ ) * 10^12]^2),
    {Eπ, (10^Eγ) +  $\frac{E\pi_{rep}^2}{4 * (10^Eγ)}$ , 10^16}, MaxRecursion → 20] / erg2ev],
  {Eγ, Log10[10^1], Log10[10^19]}, Frame → True, FrameLabel →
    {"Log10 Eγ [eV]", "Log10 Lγ<sup>PP</sup> [erg/s]"}, Axes → False]
```

Proton²

Observaciones

$$\text{radio} := \frac{5.4 * 10^{-6}}{8.6 * 10^{-6}} \mid \frac{8.4 * 10^{-14} * f2L}{1.1 * 10^{-13} * f2L}$$

$$\text{ex} := \begin{array}{c|c} 5.4 * 10^2 & 4.42 * 10^{-10} * f2L \\ \hline 1.6 * 10^3 & 4.05 * 10^{-10} * f2L \\ \hline 3.4 * 10^3 & 3.12 * 10^{-10} * f2L \\ \hline 6.3 * 10^3 & 2.29 * 10^{-10} * f2L \\ \hline 8.6 * 10^3 & 1.69 * 10^{-10} * f2L \\ \hline 1.4 * 10^4 & 1.30 * 10^{-10} * f2L \\ \hline 2.2 * 10^4 & 8.04 * 10^{-11} * f2L \\ \hline 2.9 * 10^4 & 4.55 * 10^{-11} * f2L \end{array}$$

$$\text{gamlat} := \begin{array}{c|c} 7.4 * 10^8 & 5.4 * 10^{-12} * f2L \\ \hline 1.8 * 10^9 & 4.5 * 10^{-12} * f2L \\ \hline 4.6 * 10^9 & 6.6 * 10^{-12} * f2L \\ \hline 1.4 * 10^{10} & 1.0 * 10^{-11} * f2L \\ \hline 3.4 * 10^{10} & 2.1 * 10^{-11} * f2L \\ \hline 1.0 * 10^{11} & 1.9 * 10^{-11} * f2L \\ \hline 2.5 * 10^{11} & 1.8 * 10^{-11} * f2L \end{array}$$

$$\text{gamhess} := \begin{array}{c|c} 2.9 * 10^{11} & 4.4 * 10^{-11} * f2L \\ \hline 3.4 * 10^{11} & 3.3 * 10^{-11} * f2L \\ \hline 7.4 * 10^{11} & 2.6 * 10^{-11} * f2L \\ \hline 1.4 * 10^{12} & 3.4 * 10^{-11} * f2L \\ \hline 4.6 * 10^{12} & 2.8 * 10^{-11} * f2L \\ \hline 5.4 * 10^{12} & 2.4 * 10^{-11} * f2L \\ \hline 6.3 * 10^{12} & 2.0 * 10^{-11} * f2L \\ \hline 8.6 * 10^{12} & 1.5 * 10^{-11} * f2L \\ \hline 1.8 * 10^{13} & 9.9 * 10^{-12} * f2L \\ \hline 3.4 * 10^{13} & 1.2 * 10^{-11} * f2L \\ \hline 4.0 * 10^{13} & 3.6 * 10^{-12} * f2L \\ \hline 8.6 * 10^{13} & 2.3 * 10^{-12} * f2L \end{array}$$

$$8.4 * 10^{-14} * f2L$$

$$2.26141 \times 10^{33}$$

```
Show[Plot[{Log[10, L[10^(Eγ)/erg2ev]],
  Log10[(10^Eγ)^2 * V * fvol * NIntegrate[n * σ[Eγ, Ee] * I1[Ee], {Ee, 10^Eγ, ∞},
    MaxRecursion → 15] * ev2erg], Log[10, (10^Eγ)^2 * fvol * V *  $\frac{2 * c * n}{\kappa}$  *
  Ap * 10^-27 NIntegrate[ $\frac{1}{\sqrt{E\pi^2 - E\pi_{rep}^2}}$  (Eprep +  $\frac{E\pi}{\kappa}$ )^-α * e^- $\frac{(E_{prep} + \frac{E\pi}{\kappa})}{E_{pmax}}$  *
    (34.3 + 1.88 * Log[(Eprep +  $\frac{E\pi}{\kappa}$ ) * 10^12] + 0.25 * Log[(Eprep +  $\frac{E\pi}{\kappa}$ ) * 10^12]^2),
    {Eπ, (10^Eγ) +  $\frac{E\pi_{rep}^2}{4 * (10^Eγ)}$ , 10^16}, MaxRecursion → 20] / erg2ev],
  Log[10, luminosidadIC[10^Eγ]/erg2ev]], {Eγ, Log[10, 10^-6],
  Log[10, 10^15]}, Axes → False, Frame → True,
  FrameLabel → {"Log10[Eγ/eV]", "Log10[L/(erg/s)]"}],
  ListPlot[{Log10[radio], Log10[ex], Log10[gamlat], Log10[gamhess]}],
  PlotRange → {{-6, 16}, {20, 39}},
  PlotRangeClipping → True,
  Frame → True,
  GridLines → Automatic,
  GridLinesStyle → GrayLevel[.9],
  Axes → False]
```

NIntegrate::izero : Integral and error estimates are 0 on all integration subregions. Try increasing the value of the MinRecursion option. If value of integral may be 0, specify a finite value for the AccuracyGoal option. >>

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General::stop : Further output of NIntegrate::izero will be suppressed during this calculation. >>

NIntegrate::inumr : The integrand

$$\left(2.57703 \times 10^{47} \ll 3 \gg \left(1 + \frac{5.00989 \times 10^{-13} \left(1 - \frac{65344.8}{(1 + \text{Times}[\ll 2 \gg]) \ll 1 \gg \text{Eph}} \right)}{\left(1 - \frac{\ll 23 \gg}{\text{Ee}} \right)^2 \left(1 + \frac{1.00099 \times 10^{-6}}{\text{Plus}[\ll 2 \gg] \text{Ee}} \right) \text{Ee}^2} - \ll 1 \gg + \frac{65344.8}{\left(1 - \frac{\ll 23 \gg}{\text{Ee}} \right) \ll 1 \gg \text{Eph}} + \frac{130690. \text{Log}\left[\frac{65344.8}{(1 + \text{Times}[\ll 2 \gg]) \text{Ee}^2 \text{Eph}}\right]}{\left(1 - \frac{1.00099 \times 10^{-6}}{\text{Ee}} \right) \text{Ee}^2 \text{Eph}} \right) \right) / \left((-1 + e^{4301.63 \text{Eph}}) \text{Ee}^2 \right) \text{ has evaluated to}$$

non-numerical values for all sampling points in the region with boundaries {{0, 0.023247}}. >>

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non-numerical values for all sampling points in the region with boundaries {{0, 0.023247}}. >

NIntegrate::inumr : The integrand

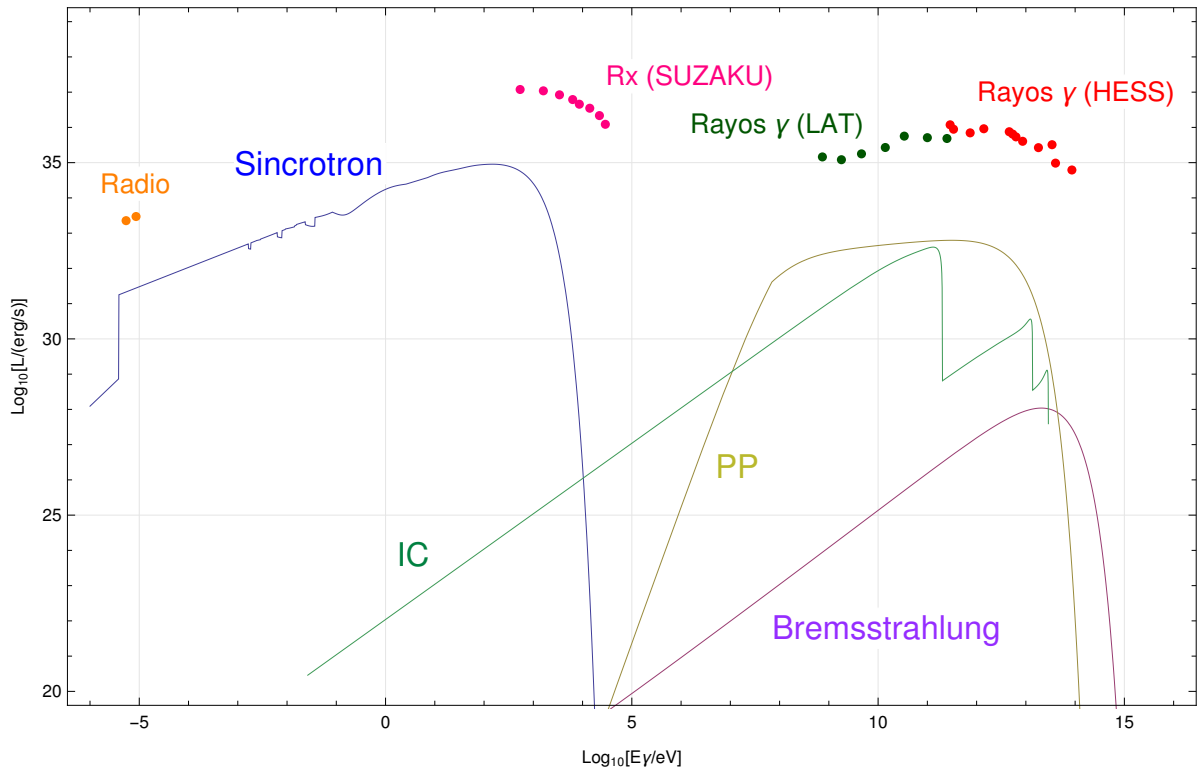
$$\left(2.57703 \times 10^{47} \ll 3 \gg \left(1 + \frac{5.00989 \times 10^{-13} \left(1 - \frac{65344.8}{(1 + \text{Times}[\ll 2 \gg]) \ll 1 \gg \text{Eph}} \right)}{\left(1 - \frac{\ll 23 \gg}{\text{Ee}} \right)^2 \left(1 + \frac{1.00099 \times 10^{-6}}{\text{Plus}[\ll 2 \gg] \text{Ee}} \right) \text{Ee}^2} - \ll 1 \gg + \frac{65344.8}{\left(1 - \frac{\ll 23 \gg}{\text{Ee}} \right) \ll 1 \gg \text{Eph}} + \frac{130690. \text{Log} \left[\frac{65344.8}{(1 + \text{Times}[\ll 2 \gg]) \text{Ee}^2 \text{Eph}} \right]}{\left(1 - \frac{1.00099 \times 10^{-6}}{\text{Ee}} \right) \text{Ee}^2 \text{Eph}} \right) \right) / \left((-1 + e^{4301.63 \text{Eph}}) \text{Ee}^2 \right) \text{ has evaluated to}$$

non-numerical values for all sampling points in the region with boundaries {{0, 0.023247}}. >

General::stop : Further output of NIntegrate::inumr will be suppressed during this calculation. >

NIntegrate::ncvb : NIntegrate failed to converge to prescribed accuracy after 9 recursive bisections in Ee near {Ee} = {6.69621 × 10⁶}. NIntegrate obtained 5.8486847379484`*^20 and 1.6541511433548839`*^19 for the integral and error estimates. >

\$Aborted




```
Show[ListPlot[{Log10[radio], Log10[ex], Log10[gamlat], Log10[gamhess]}]]
```

