In[2582]:=

```
Clear["Global`*"]
Needs["Notation`"]
Needs["PlotLegends`"]
Needs["CustomTicks`"]
```

$\text{Msun} = 2\times 10^{33};$

$\text{Mdotsol} = \left(\dfrac{\text{Msun}}{3.15\times 10^{7}}\right)$

$G = 6.67\times 10^{-8};$

$c = 3\times 10^{10};$

$\sigma = 5.67\times 10^{-5};$

$\text{kb} = 1.38\times 10^{-16};$

$\text{mp} = 1.67\times 10^{-24};$

$\text{me} = 9.11\times 10^{-27};$

$h = 6.63\times 10^{-27}$

Symbolize[$\dot{M}$]

Symbolize[$\hat{\varkappa}$]

Symbolize[M_7]

Symbolize[$\alpha_{0.3}$]

Symbolize[$\dot{m}$]

Symbolize[$\dot{M}_{Edd}$]

Symbolize[L_{Edd}]

Symbolize[R_S]

Symbolize[$\epsilon_{0.1}$]

Symbolize[q_{-3}]

Symbolize[f_{-2}]

Symbolize[α_{-1}]

Symbolize[$\dot{m}_{-1}$]

$\text{fiducial} = \{\alpha_{0.3} \to 1,\ \mu 0 \to 0.615,\ \mu e \to 0.875,\ \epsilon_{0.1} \to 1,\ \dot{m} \to 0.1,\ \varkappa 0 \text{ -> } 1,\ \text{ft} \to 3/8,\ b \to 1\}$

$M = 10^{7}\ \text{Msun}\ M_7;$

$\varkappa = \mu e\ 0.4\ \varkappa 0;$

$\alpha = 0.3\ \alpha_{0.3};$

$m = \mu 0\ \text{mp};$

```
(*Get rid of explicit opacity dependence in the Eddington
   Luminosity. This is for consistency with Goodman 2003 Goodman &
 Tan 2004 -- i.e. to get a consistent opacity dependence in the . Not
 to mention that the expression which I had for the,
central temperature implicitly sets the opacity to be the electron scattering in Ṁ*)
```

$$L_{Edd} = 4\pi G \frac{M}{0.4\,\mu e} c\,;$$

$$\dot{M}_{Edd} = \frac{L_{Edd}}{c^2\,\epsilon_{0.1}\,0.1};$$

$$\dot{M} = \dot{m}\,\dot{M}_{Edd};$$

$$R_S = 2G\frac{M}{c^2};$$

$$R = 10^3\,R_S\,r3;$$

$$Q = G\frac{M}{R^3};$$

$$Teff = \left(\frac{3}{8\pi\sigma}\frac{G M \dot{M}}{R^3}\right)^{1/4} \text{ // PowerExpand // Simplify;}$$

```
Print["Teff= ", Teff]
```

$$(*Tc=8\ 10^4\ \mu0^{1/5}\ \mu e^{-1/5}\ r3^{-9/10}\ M_7{}^{-1/5}\ \alpha_{0.3}{}^{-1/5}\ f_T{}^{1/5}\ \left(\frac{\dot{m}}{\epsilon_{0.1}}\right)^{2/5}\ \hat{\kappa}^{1/5}\ ;*)$$

$$(*\sqrt{kb\ \frac{Tc}{\mu 0\ mp}}\ *)$$

$$Tc = \left((\kappa\, m) \middle/ \left(16\,\pi^2\,\alpha\,\beta^{b-1}\,\sigma\,kb\right)\right)^{1/5} \dot{M}^{2/5}\,Q^{3/10}\,ft^{1/5} \text{ // PowerExpand[\#] \& ;}$$

```
Print["Tc= ", Tc]
(*Get different dependences on β and on ft from 2 seemingly equivalent expressions*)
```

$$\Sigma = \frac{2}{\kappa\, ft}\frac{Tc^4}{Teff^4} \text{ // PowerExpand}\Big[\#(*,\ Assumptions\to$$
$$\{\beta>0, b>0,\ M_7>0,\ r3>0,\ \mu0>0,\ \mu e>0,\ \dot{m}>0,\ \epsilon_{0.1}>0,\ ft>0,\ \alpha_{0.3}>0,\ \kappa0>0\}*)\Big] \text{ \& // Simplify ;}$$

$$\Sigma 2 = \frac{\dot{M}}{3\pi\, 0.3\,\alpha_{0.3}\,\beta^b \left(\frac{1}{\beta} kb \frac{Tc}{m}\right)}\left(G\frac{M}{R^3}\right)^{1/2};$$

```
Print["Σ=  ", Σ]
```

$$(*H=\left(\frac{1}{R_s}\frac{(\beta\ kb\ Tc/m)\wedge(1/2)}{Q\wedge(1/2)}\right)\text{//PowerExpand}\Big[\#,$$
$$Assumptions\to\{\beta>0, b>0,\ M_7>0,\ r3>0,\ \mu0>0,\ \mu e>0,\ \dot{m}>0,\ \epsilon_{0.1}>0,\ ft>0,\ \alpha_{0.3}>0,\ \kappa0>0\}\Big]\&;*)$$

$$H = \left(\frac{(\beta\ kb\ Tc\ /\ m)\wedge(1/2)}{Q\wedge(1/2)}\ /.\ \beta\to 1\right) \text{ // PowerExpand}\Big[\#(*,\ Assumptions\to$$

```
{β>0,b>0, M7>0, r3>0, μ0>0, μe>0, ṁ>0, ϵ0.1>0, ft>0, α0.3>0, ϰ0>0}*)] & // Simplify;
Hi = 10 Rs ϰ0 ṁ/ϵ0.1 ft;
Print["H/Rs (inner region) = ", Hi/Rs]
Print["H/Rs (middle region) = ", H/Rs]


(*Teff  (0.4 μe ϰ̂ Σ/2 fT)^(1/4) //
 PowerExpand[#, Assumptions→{M7>0, r3>0, μ0>0, μe>0, ṁ>0, ϵ0.1>0, fT>0, α0.3>0}]&*)
(*β=(3 c/(8 σ) (kb/(μ0 mp))^(1/2) Σ Sqrt[Q]/Tc^(7/2))^2 //
   Simplify[#, Assumptions→{M7>0, r3>0, μ0>0, α0.3>0,  μe>0, ṁ>0, ϰ̂>0, ϵ0.1>0, fT>0}]&
  Σ Sqrt[Q]/(2 Sqrt[β kb Tc/(μ0 mp)]) //
  Simplify[#, Assumptions→{M7>0, r3>0, μ0>0, α0.3>0,  μe>0, ṁ>0, ϰ̂>0, ϵ0.1>0, fT>0}]&*)
```

In[2630]:=

```
βeqn = Sqrt[β]/(1 - β) == (3 c/(8 σ) (kb/(μ0 mp))^(1/2) Σ Sqrt[Q]/Tc^(7/2)) // PowerExpand // Simplify
inner = r3 /. ((Solve[βeqn /. {β → 0.5}, r3]) /. b → 1);
inner1 = inner[[1]] /. fiducial;
H1 = H /. fiducial
Hi1 = Hi /. fiducial
H2 = If[r3 < inner1, Log[10, Hi1/R], Log[10, H1/R]]
(*ContourPlot[(Log[10, Hi1/R]/.{r3→10^x,M7→10^y}),{x, -1, 1}, {y,-2, 2},
 FrameLabel→{"Log[r3]","Log[M7]"}, ContourShading→False, ContourLabels→True ]*)
ContourPlot[(H2 /. {r3 → 10^x, M7 → 10^y}) /. {r3 → 10^x, M7 → 10^y}, {x, -1, 1}, {y, -2, 2},
 FrameLabel → {"Log[r3]", "Log[M7]"}, ContourShading → False, ContourLabels → True ]
```

In[2637]:=

```
Teff1 = Teff /. fiducial;
Tc1 = Tc /. fiducial;
Σ1 = Σ /. fiducial;
Q1 = Q /. fiducial;

Σ1 /. {r3 → 0.1, M7 → 100}
Σ1 /. {r3 → 1, M7 → 0.01}
Q1 /. {r3 → 0.1, M7 → 0.01}
Q1 /. {r3 → 1, M7 → 100}

Needs["PlotLegends`"]
ΣMax = Log[10, Σ1] /. {r3 → 0.1, M7 → 100};
ΣMin = Log[10, Σ1] /. {r3 → 1, M7 → 0.01};
QMax = Log[10, Q1] /. {r3 → 0.1, M7 → 0.01};
QMin = Log[10, Q1] /. {r3 → 1, M7 → 100};
TMin = Log[10, Teff1] /. {r3 → 1, M7 → 100};
TMax = Log[10, Teff1] /. {r3 → 0.1, M7 → 0.01};


ΣLegend = Graphics[
   Legend[Function[{x}, ColorData["Rainbow"][x]], 50, NumberForm[ΣMin, 2] // ToString,
    NumberForm[ΣMax, 2] // ToString, LegendShadow → False, LegendBorderSpace → 2]];
QLegend = Graphics[Legend[Function[{x}, ColorData["Rainbow"][x]], 50,
    NumberForm[QMin, 2] // ToString, NumberForm[QMax, 2] // ToString,
    LegendShadow → False, LegendBorderSpace → 2]];
TeffLegend = Graphics[Legend[Function[{x}, ColorData["Rainbow"][x]], 50,
    NumberForm[TMin, 2] // ToString, NumberForm[TMax, 2] // ToString,
    LegendShadow → False, LegendBorderSpace → 2]];


SetOptions[ContourPlot, ImageSize → Medium];
rainbow = Function[{x}, ColorData["Rainbow"][x]]
GraphicsRow[
 GraphicsRow /@ {{ContourPlot[Log[10, Σ1] /. {r3 → 10^x, M7 → 10^y}, {x, -1, 0}, {y, -2, 2},
      PlotLabel → "Σ Plot", FrameLabel → {"Log[r3]", "Log[M7]"} ,
      ColorFunction → rainbow, ContourShading → False, ContourLabels → True]},
   {ContourPlot[Log[10, Q1] /. {r3 → 10^x, M7 → 10^y}, {x, -1, 0}, {y, -2, 2},
      PlotLabel → "Q Plot", FrameLabel → {"Log[r3]", "Log[M7]"},
      ColorFunction → rainbow, ContourShading → False, ContourLabels → True]},
   {ContourPlot[{ Log[10, Teff1] /. {r3 → 10^x, M7 → 10^y}}, {x, -1, 0},
      {y, -2, 2}, PlotLabel → "Teff Plot", FrameLabel → {"Log[r3]", "Log[M7]"},
      ColorFunction → rainbow, ContourShading → False, ContourLabels → True]}}]
```

In[2658]:=

```
(*Note we are ignoring the order unity term λ and also
 terms with δr_i/r_H. We also roughly equate the term (δr_i/r_s) with 0;
Trying to repoduce results from Haiman, Koscis, Loeb 2012*)
Clear[rs2]
```

$$kmg = 23\,(\alpha_{-1})^{1/2}\,(\dot{m}_{-1})^{-3/8}\,M_7{}^{-3/4}\,(q_{-3})^{5/8}\,(rs2)^{-7/8};$$

$$a = 0.465\,(\alpha_{-1})\,(f_{-2})^{-5/4}\,(q_{-3})^{-13/12}\,(M_7)^{-1/4}\,(rs2)^{5/8};$$

$$kmos = 0.97\,(\alpha_{-1})^{-2/11}\,(\dot{m}_{-1})^{-1}\,(M_7)^{1/22}\,(f_{-2})^{5/22}\,(q_{-3})^{5/11}\,(rs2)^{39/44}\,(\text{Max}[\text{ProductLog}[0,-a]\,//\,\text{Abs},\ \text{ProductLog}[-1,-a]\,//\,\text{Abs}])^{13/11};$$

$$kmou = 1.3\,(\alpha_{-1})^{-2}\,(\dot{m}_{-1})^{-1}\,(M_7)^{1/2}\,(f_{-2})^{5/2}\,(q_{-3})^{5/2}\,(rs2)^{-1/4}\left(1+\left(10^{-3}\,\frac{q_{-3}}{3}\right)^{1/9}\right)^{-115/24};$$

$$kmou = kmou\ /.\ \{\alpha_{-1}\to 1,\ \dot{m}_{-1}\to 1,\ f_{-2}\to 1\};$$

$$kmos = kmos\ /.\ \{\alpha_{-1}\to 1,\ \dot{m}_{-1}\to 1,\ f_{-2}\to 1\};$$

$$kmg = kmg\ /.\ \{\alpha_{-1}\to 1,\ \dot{m}_{-1}\to 1,\ f_{-2}\to 1\};$$

$$rs2 = rs2\ /.\ \text{Solve}\left[Pd == 2\,\frac{\pi}{\sqrt{G\,\frac{M}{(rs2\,100\,R_s)^3}}}\,\frac{1}{(3600\times 24)},\ rs2\right][[-1]];$$

$$(*kmos=kmos/.\{M_7\to 10^2\}\quad kmou=kmou/.\{M_7\to 10^2\}\quad kmg=kmg/.\{M_7\to 10^2\}*)$$

$$sub = \{M_7\to 1,\ Pd\to 10^{lp},\ q_{-3}\to 10^{lq+3}\};$$

```
ContourPlot[Min[kmg /. sub,
   kmou /. sub,
   kmos /. sub], {lp, 0, Log[10, 3000]}, {lq, -3, -1},
 FrameTicks → {LogTicks, LogTicks, LogTicks, LogTicks},
 ColorFunctionScaling → False, PlotRange → All, PlotRange → All,
 Contours → {2, 10, 20, 50, 100, 150}, ContourLabels → True, ContourShading → None]
```

$$sub = \{M_7\to 10^{-2},\ Pd\to 10^{lp},\ q_{-3}\to 10^{lq+3}\};$$

```
ContourPlot[Min[kmg /. sub,
   kmou /. sub,
   kmos /. sub], {lp, -2, Log[10, 30]}, {lq, -3, -1},
 FrameTicks → {LogTicks, LogTicks, LogTicks, LogTicks},
 ColorFunctionScaling → False, PlotRange → All, PlotRange → All,
 Contours → {2, 10, 20, 50, 100, 250, 500}, ContourLabels → True, ContourShading → None]

RegionPlot[{(kmou /. sub) == Min[kmg /. sub,
     kmou /. sub, kmos /. sub], (kmg /. sub) == Min[kmg /. sub,
     kmou /. sub, kmos /. sub]}, {lp, -3, Log[10, 30]},
 {lq, -3, -0.75}, FrameTicks → {LogTicks, LogTicks, LogTicks, LogTicks}]
```

```
In[2672]:= Clear[rs2]

fiducial = {α0.3 → 1, μ0 → 0.615, μe → 0.875, ϵ0.1 → 1, ṁ → 0.1, κ0 -> 1, ft → 3 / 8, b → 1};
fiducial2 = {α-1 → 3, ṁ-1 → 1, f-2 → 1, q-3 → 10};

kmg = 23 (α-1)^(1/2) (ṁ-1)^(-3/8) M7^(-3/4) (q-3)^(5/8) (rs2)^(-7/8);
a = 0.465 (α-1) (f-2)^(-5/4) (q-3)^(-13/12) (M7)^(-1/4) (rs2)^(5/8);
kmos = 0.97 (α-1)^(-2/11) (ṁ-1)^(-1) (M7)^(1/22) (f-2)^(5/22) (q-3)^(5/11)
   (rs2)^(39/44) (Max[ProductLog[0, -a] // Abs, ProductLog[-1, -a] // Abs])^(13/11);
kmou = 1.3 (α-1)^(-2) (ṁ-1)^(-1) (M7)^(1/2) (f-2)^(5/2) (q-3)^(5/2) (rs2)^(-1/4) (1 + (10^(-3) q-3/3)^(1/9))^(-115/24) ;

{kmou, kmos, kmg} = {kmou, kmos, kmg} /. fiducial2;

ks = Min[kmou, kmos, kmg];

Teff1 = Teff /. fiducial /. r3 → rs2 / 20;
Σ1 = Σ /. fiducial /. r3 → rs2 / 20;

(*TcMin=Log[10, Tc2]/.{r3→10, M7→100};
TcMax=Log[10, Tc2]/.{r3→0.1, M7→0.01};
TeffMin=Log[10, Teff2]/.{r3→10, M7→100};
TeffMax=Log[10, Teff2]/.{r3→0.1, M7→0.01};*)

(*TcLegend=Graphics[Legend[rainbow, 50, TcMin//ToString,
   TcMax//ToString, LegendShadow→False, LegendBorderSpace→2]];
TeffLegend=Graphics[Legend[rainbow, 50, TeffMin//ToString,
   TeffMax//ToString, LegendShadow→False, LegendBorderSpace→2]];*)

(*ColorFunction→Function[{x}, ColorData["Rainbow"][x]]*)

(*c1=ContourPlot[{Log[10,Teff1]}/.{r3→10^x,M7→10^y}, {x, -1, 1},
  {y,-2, 2}, ContourShading→False, ContourStyle→Directive[Blue],
  PlotLabel→"Q Contour Plot", FrameLabel→{"Log[r3]","Log[M7]"}, Contours→contours]*)
kbdry = ContourPlot[ks /. {rs2 → 10^x, M7 → 10^y}, {x, 0, 2}, {y, -2, 2},
   ContourShading → None,  Contours → {1}, ContourStyle → Directive[Red]];

cteff1 = ContourPlot[{Log[10, (1 + ks)^(1/4)]} /. {rs2 → 10^x, M7 → 10^y}, {x, 0, 1}, {y, -2, 2},
   PlotLabel → "Perturbed Teff", FrameLabel → {"Log[rs2]", "Log[M7]"}, ContourShading → None,
   ContourLabels → True, RegionFunction → Function[{x, y}, (ks /. {rs2 → 10^x, M7 → 10^y} ) > 1]];
cteff2 = ContourPlot[{Log[10, Teff1 (1 + ks)^(1/4)]} /. {rs2 → 10^x, M7 → 10^y},
   {x, 0, 1}, {y, -2, 2},  PlotLabel → "Perturbed Teff",
   FrameLabel → {"Log[rs2]", "Log[M7]"}, ContourShading → None, ContourLabels → True,
   RegionFunction → Function[{x, y}, (ks /. {rs2 → 10^x, M7 → 10^y} ) > 1]];

cΣ1 = ContourPlot[{Log[10, (1 + ks)^(3/5)]} /. {rs2 -> 10^x, M7 → 10^y}, {x, 0, 1}, {y, -2, 2},
   PlotLabel → "Perturbed Σ", FrameLabel → {"Log[rs2]", "Log[M7]"}, ContourShading → None,
```

```
    ContourLabels → True, RegionFunction → Function[{x, y}, (ks /. {rs2 → 10^x, M7 → 10^y} ) > 1]];
cΣ2 = ContourPlot[{Log[10, Σ1 (1 + ks)^(3/5)]} /. {rs2 -> 10^x, M7 → 10^y}, {x, 0, 1}, {y, -2, 2},
    PlotLabel → "Perturbed Σ", FrameLabel → {"Log[rs2]", "Log[M7]"}, ContourShading → None,
    ContourLabels → True, RegionFunction → Function[{x, y}, (ks /. {rs2 → 10^x, M7 → 10^y} ) > 1]];

βtest =
  Hold[(β /. Solve[Sqrt[β]/(1 - β) == (3.94 r3^(21/20))/(M7^(1/10)) (1 + ks)^(-4/5) /. {r3 → rs2 / 20} /. {rs2 -> 10^y, M7 → 10^x},
        β])[[1]] < 0.5]

RegionPlot[ReleaseHold[βtest], {x, 0, 1}, {y, -2, 2}, MaxRecursion → 1]

cH = ContourPlot[{Log[10, (1 + ks) Hi/R /. fiducial /. r3 → (rs2 / 20)] } /. {rs2 -> 10^x, M7 → 10^y},
    {x, 0, 1}, {y, -2, 1}, PlotLabel → "Perturbed H",
    FrameLabel → {"Log[rs2]", "Log[M7]"}, ContourShading → None, ContourLabels → True,
    RegionFunction → Function[{x, y}, (ks /. {rs2 → 10^x, M7 → 10^y} ) > 1]];
cH2 = ContourPlot[{Log[10, (1 + ks)^(1/5) H/R /. fiducial /. r3 → (rs2 / 20)]} /.
     {rs2 -> 10^x, M7 → 10^y}, {x, 0, 1}, {y, 1, 2}, PlotLabel → "Perturbed H",
    FrameLabel → {"Log[rs2]", "Log[M7]"}, ContourShading → None, ContourLabels → True,
    RegionFunction → Function[{x, y}, (ks /. {rs2 → 10^x, M7 → 10^y} ) > 1]];

Show[cteff1, kbdry]
Show[cteff2, kbdry]
Show[cΣ1, kbdry]
Show[cΣ2, kbdry]
Show[cH, kbdry]
Show[cH2, kbdry]
(*c2=ContourPlot[{Log[10,Tc2]}/.{r3→10^x,M7→10^y}, {x, -1, 1},
  {y,-2, 2},  PlotLabel→"Perturbed Tc", FrameLabel→{"Log[r3]","Log[M7]"},
  ContourShading→None, ContourLabels→True,ColorFunction→rainbow]*)
```

In[2701]:=

```
(*fiducial2={rs2→20r3, α_-1→3, ṁ_-1→1,  f_-2→1};
test={r3→0.05, M_7→1, q_-3→100};

q=q_-3 10^-3;

rs=R;
rh=(q/3)^(1/3) rs;
Ωs=Sqrt[G M/rs^3];
r=rs+y rh;
Ω=Sqrt[G M/r^3];
ri=rs+rh;
Ω0=Sqrt[G M/ri^3];
Δ=r-rs;
Δi=ri-rs;
lower=ri/rs;

upper=r/rs


   ξr=Function[y, NIntegrate[x^(-7/6) (1-x^(-3/2))^(-1/6) (x-1)^(-10/3), {x, lower/.test, upper/.test}]]
   ψ=2/3 Beta[(Ωs-Ω)/Ωs, 5/26, 7/13]-2/3 Beta[(Ωs-Ω0)/Ωs, 5/26, 7/13];
(*Scale height in units of Scwarzscild*)
Hpert=9.5 (α_-1)^(-2/11) (M_7)^(1/22) (f_-2)^(5/22) (q_-3)^(5/11) (rs2)^(39/44) ((Ωs-Ω)/Ωs)^(5/26) (r/rs)^(5/26) ψ^(2/11)/.fiducial2/.test;

Hpert2=0.065 (α_-1)^-2 (M_7)^(1/2) (f_-2)^(5/2) rs2^(-1/4) (r/rs)^(-5/24)/.fiducial2/.test;
(*Flux perturbation in unsaturated regime*)
Fpert=
 9.8 10^14  (α_-1)^(-2/11) (M_7)^(-21/22) (f_-2)^(5/22) (q_-3)^(5/11) (rs2)^(-93/44) ((Ωs-Ω)/Ωs)^(5/26) (r/rs)^(-73/26) ψ^(2/11)/.fiducial2/.
  test;
(*Flux perturbation in saturated regime*)
Fpert2=6.8 10^12  (α_-1)^-2 (M_7)^(-1/2) (f_-2)^(5/2) (q_-3)^(10/3) (rs2)^(-13/4) (r/rs)^(-77/24) (Δ/rs)^(-5/2)/.fiducial2/.test;

LogPlot[{2 Hpert ,  (r-rs)/R_s/.test}, {y, 1, 10}]
  p1=LogPlot[{Fpert r^2/.test}, {y, 1, 10}]
SetDirectory[NotebookDirectory[]]
   perturbed=Import["perturbed.csv"]
   perturbed[[All, 1]]=(perturbed[[All,1]]-(rs/R_s))/(rh/R_s)/.test;
p2=ListLogPlot[perturbed, PlotStyle→Directive[Red]];
Show[p2, p1]


Fpert2=6.8 10^12  (α_-1)^-2 (M_7)^(-1/2) (f_-2)^(5/2) (q_-3)^(10/3) (rs2)^(-13/4) (r/rs)^(-77/24) (Δ/rs)^(-5/2)/.fiducial2/.test
    Fpert2=Fpert2/.y→perturbed[[All,1]]

(*x^(-7/6) (1-x^(-3/2))^(-1/6) (x-1)^(-10/3), *)*)
```

In[2702]:=

```
(*rs=(R_S/2) 100 rs2;
ΩS=Sqrt[G M/rs^3]
    fiducial={α_{0.3}→1, μ0→0.615, μe→0.875,ϵ_{0.1}→1, ṁ→0.1, κ0->1, ft→3/8, b→1}
     βeqn/.{b→1, β→0.5, ft→3/4, r3→300}
     ((Sqrt[β]/(1-β)==(8π)^(4/5) C (kb/(μ0 mp))^(2/5)/(3^(9/10) (α σ)^(1/10) κ^(9/10)) Q^(9/20)/((ṀQ)^(4/5) (1)^(4/5)))//PowerExpand)/.fiducial*)
```