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

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

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

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

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

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

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

$$mp = 1.67\times 10^{-27};$$

$$me = 9\times 10^{-31};$$

$$\varkappa es = 0.4;$$

$$\text{Symbolize}\left[\dot{M}\right]$$

$$\text{Symbolize}\left[\hat{\varkappa}\right]$$

$$\text{Symbolize}\left[M_7\right]$$

$$\text{Symbolize}\left[\alpha_{0.3}\right]$$

$$\text{Symbolize}\left[\dot{m}\right]$$

$$\text{Symbolize}\left[\dot{M}_{Edd}\right]$$

$$\text{Symbolize}\left[L_{Edd}\right]$$

$$\text{Symbolize}\left[R_S\right]$$

$$\text{Symbolize}\left[\epsilon_{0.1}\right]$$

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

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

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

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

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

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

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

$$Teff = \left(\frac{3}{8\pi\sigma}\,\frac{G M \dot{M}}{R^3}\right)^{1/4}\ \text{// Simplify}[\#,\ \text{Assumptions}\to\{M_7>0,\ r3>0\}]\ \&$$

$$Tc = 8\times 10^{4}\,\mu 0^{1/5}\,\mu e^{-1/5}\, r3^{-9/10}\, M_7{}^{-1/5}\,\alpha_{0.3}{}^{-1/5}\, f_T{}^{1/5}\left(\frac{\dot{m}}{\epsilon_{0.1}}\right)^{2/5}\hat{\varkappa}^{1/5};$$

$$\Sigma = \frac{\dot{M}}{3\pi\,\frac{kb\,Tc}{\mu 0\,mp}\,0.3\,\alpha_{0.3}\left(G\,\frac{M_7\,10^{7}\,Msun}{R^3}\right)^{1/2}}\ \text{// Simplify}[\#,\ \text{Assumptions}\to\{M_7>0,\ r3>0\}]\ \&$$

6.34921×10^{25}

Symbolize::bsymbexs :
Warning: The box structure attempting to be symbolized has a similar or identical symbol already defined, possibly overriding previously symbolized box structure. >>

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$$\frac{5.12066 \times 10^{-14}}{M_7^2\, r3^3}$$

$$6229.49 \left(\frac{\dot{m}}{M_7\, r3^3\, \epsilon_{0.1}\, \hat{\kappa}\, \mu e}\right)^{1/4}$$

$$\frac{169.123 \left(\frac{\dot{m}}{\epsilon_{0.1}}\right)^{3/5} \mu 0^{4/5}}{\alpha_{0.3}^{4/5}\, \hat{\kappa}^{6/5}\, \mu e^{4/5} \left(\frac{r3^3\, f_T}{M_7}\right)^{1/5}}$$

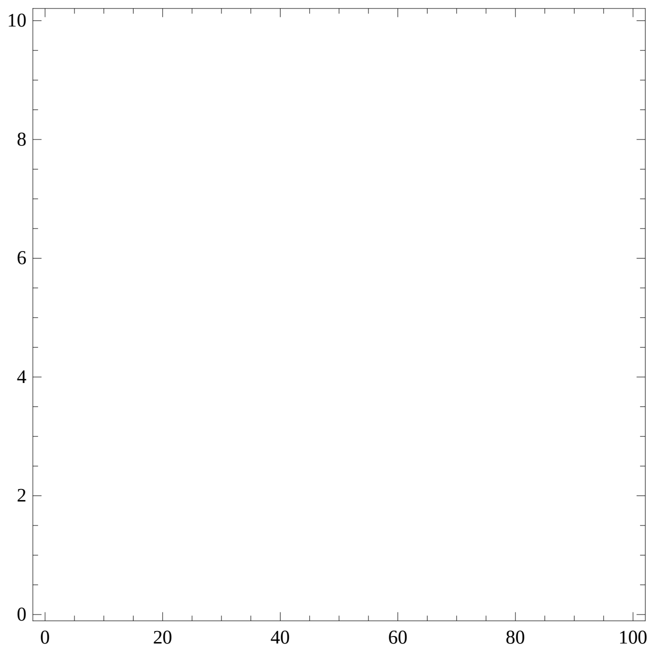
```
(*Compton y parameter*)
```

$$y = 4\,kb\,\frac{Tc1}{me\,c^2}\,Max\left[\Sigma\,\frac{\varkappa es}{2},\ \left(\Sigma\,\frac{\varkappa es}{2}\right)^2\right]\ /.$$

$$\left\{\alpha_{0.3}\to 1,\ \mu 0\to 0.615,\ \mu e\to 0.875,\ \epsilon_{0.1}\to 1,\ \dot{m}\to 0.1,\ \hat{\varkappa}\to 1,\ f_T\to 3/8\right\}\ //\ Simplify$$

RegionPlot[y > 1, {M_7, 0.01, 100}, {r3, 0.1 , 10}]

$$6.81481\times 10^{-7}\ Tc1\ Max\left[\frac{60.791}{\left(\frac{r3^3}{M_7}\right)^{2/5}},\ \frac{7.79686}{\left(\frac{r3^3}{M_7}\right)^{1/5}}\right]$$



```
Teff1 = Teff /. {α0.3 → 1, μ0 → 0.615, μe → 0.875, ϵ0.1 → 1, ṁ → 0.1, κ̂ → 1, fT → 3 / 8};
Σ1 = Σ /. {α0.3 → 1, μ0 → 0.615, μe → 0.875, ϵ0.1 → 1, ṁ → 0.1, κ̂ → 1, fT → 3 / 8};
Q1 = Q /. {α0.3 → 1, μ0 → 0.615, μe → 0.875, ϵ0.1 → 1, ṁ → 0.1, κ̂ → 1, fT → 3 / 8};

Σ1 /. {r3 → 0.1, M7 → 100}
Σ1 /. {r3 → 10, M7 → 0.01}
Q1 /. {r3 → 0.1, M7 → 0.01}
Q1 /. {r3 → 10, M7 → 100}

OurDir = SetDirectory[NotebookDirectory[]]
Needs["PlotLegends`"]
ΣMax = Log[10, Σ1] /. {r3 → 0.1, M7 → 100};
ΣMin = Log[10, Σ1] /. {r3 → 10, M7 → 0.01};
QMax = Log[10, Q1] /. {r3 → 0.1, M7 → 0.01};
QMin = Log[10, Q1] /. {r3 → 10, M7 → 100};
TMin = Log[10, Teff1] /. {r3 → 10, 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];
GraphicsRow[
 GraphicsRow /@ {{ContourPlot[Log[10, Σ1] /. {r3 → 10^x, M7 → 10^y}, {x, -1, 1}, {y, -2, 2},
      PlotLabel → "Suface Density Contour Plot", FrameLabel → {"Log[r3]", "Log[M7]"} ,
      ColorFunction → Function[{x}, ColorData["Rainbow"][x]]], ΣLegend},
   {ContourPlot[Log[10, Q1] /. {r3 → 10^x, M7 → 10^y}, {x, -1, 1}, {y, -2, 2},
      PlotLabel → "Q Contour Plot", FrameLabel → {"Log[r3]", "Log[M7]"},
      ColorFunction → Function[{x}, ColorData["Rainbow"][x]]], QLegend},
   {ContourPlot[{ Log[10, Teff1] /. {r3 → 10^x, M7 → 10^y}}, {x, -1, 1}, {y, -2, 2},
      PlotLabel → "Teff Contour Plot", FrameLabel → {"Log[r3]", "Log[M7]"},
      ColorFunction → Function[{x}, ColorData["Rainbow"][x]]], TeffLegend}}]
```

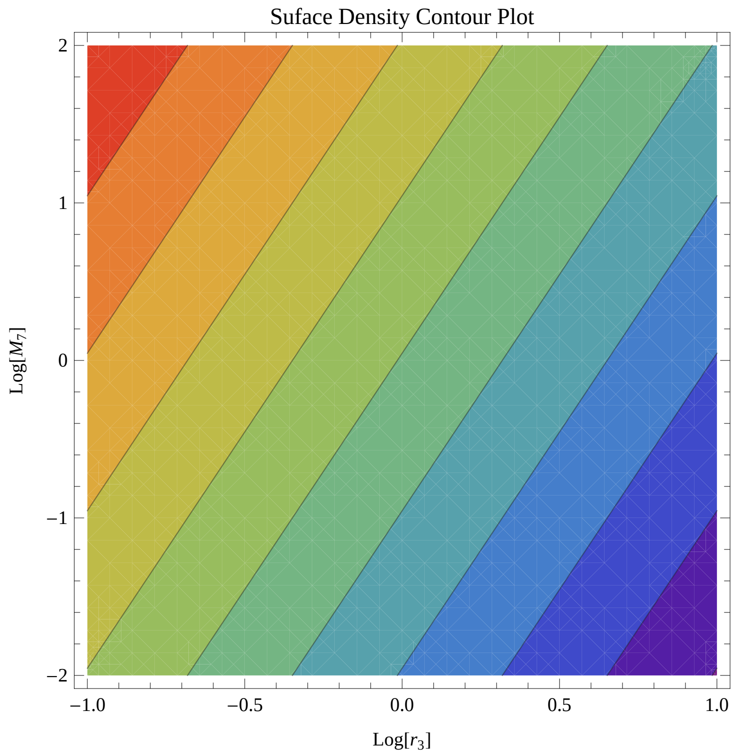
389 843.

3898.43

5.12066×10^{-7}

5.12066×10^{-21}

/home/aleksey/First_Year_Project



$0.64^{4/3}$

0.551535

$$Tc = 8 \times 10^4\ \mu 0^{1/5}\ \mu e^{-1/5}\ r3^{-9/10}\ M7^{-1/5} \left(\frac{\alpha}{0.3}\right)^{-1/5} ft^{1/5} \left(\frac{mdot}{(\epsilon / 0.1)}\right)^{2/5}\ /.$$

$$\left\{\mu 0 \to 0.615,\ \mu e \to 0.875,\ \alpha \to 0.3,\ ft \to \frac{3}{4},\ \epsilon \to 0.1,\ mdot \to 0.1\right\}$$

$$\frac{28\,020.5}{M7^{1/5}\ r3^{9/10}}$$

$3.1\ M7^{-1/5}$ /. $\{M7 \to 10^{-4}\}$

$(2.8)^{10/9}$

19.5597

3.13937

$$\rho c\,kb\,\frac{Tc}{\mu 0\,mp}\text{ /. }\{\mu 0\to 0.615,\ Tc\to 10^5,\ \rho c\to 1.5\times 10^{-8}\}$$

$$4\,\sigma\,Tc^4/(3\,c)\text{ /. }\{Tc\to 10^5\}$$

$$cs=\sqrt{\gamma\,(4\,\sigma\,Tc^4/(3\,c\,\rho c))}$$

$$H=\frac{Mdot}{3\,\pi\,\Sigma\,cs\,\alpha}\text{ /. }\{\mu 0\to 0.615,\ Tc\to 10^5,\ \Sigma\to 90000,\ Mdot\to 1.40\times 10^{24},\ \alpha\to 0.3,\ \gamma\to 4/3\}$$

$$rul=\left(\mathrm{Solve}\left[\frac{90000}{2\,H}==\rho c,\ \rho c\right]\right)[[3]]$$

$$\rho c\,kb\,\frac{Tc}{\mu 0\,mp}\text{ /. }\{\mu 0\to 0.615,\ Tc\to 10^5,\ \rho c\to 1.5\times 10^{-8}\}$$

$$4\,\sigma\,Tc^4/(3\,c)\text{ /. }rul\text{ /. }Tc\to 10^5$$

$$\frac{H}{cs}\text{ /. }rul\text{ /. }\{\mu 0\to 0.615,\ Tc\to 10^5,\ \Sigma\to 90000,\ Mdot\to 1.40\times 10^{24},\ \alpha\to 0.3,\ \gamma\to 4/3\}$$

$$(*\frac{H}{cs}\text{/.}rul$$

$$2\,\frac{\pi}{\sqrt{G\,M/R^3}}\text{/.}\{M\to M_7 10^7 Msun,\ R\to 200\ R_s,\ M_7\to 1\}*)$$

7.78685

$$\frac{56474.8}{M7^{1/5}\,r3^{9/10}}$$

$$\frac{1553.47}{M7^{4/5}\,r3^{18/5}}$$

$$39.4141\sqrt{\frac{\gamma}{M7^{4/5}\,r3^{18/5}\,\rho c}}$$

$$\frac{1.20885\times 10^{17}}{\sqrt{\frac{1}{M7^{4/5}\,r3^{18/5}\,\rho c}}}$$

$$\left\{\rho c\to\frac{5.1748\times 10^{-9}}{M7^{4/15}\,r3^{6/5}}\right\}$$

$$\frac{56474.8}{M7^{1/5}\,r3^{9/10}}$$

$$\frac{1553.47}{M7^{4/5}\,r3^{18/5}}$$

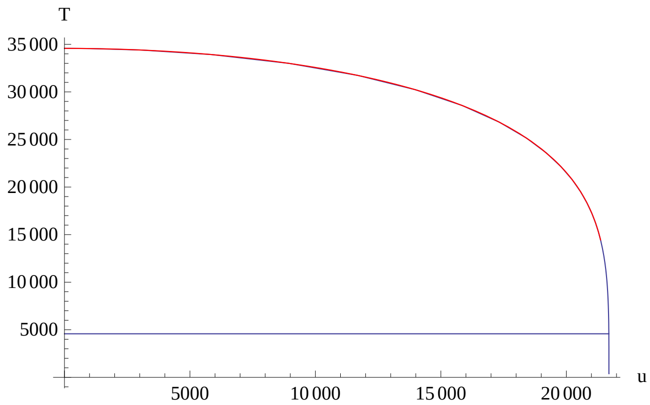
$$1.3745\times 10^{7}\,M7^{8/15}\,r3^{12/5}$$

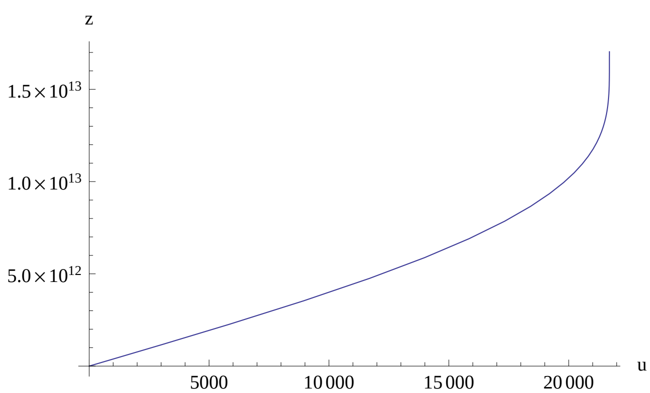
```
(*Example of a particular profile*)
M = 10^7 Msun;
μe = 1;
μ0 = 0.615;
κes = 0.4 μe;
(*Import profile and extract physical parameters*)
MyFile = "profile-43395-0.1-700";
MyFileP = StringSplit[MyFile, "-"] // #[[2 ;;]] &;
MyFileP = ToExpression /@ MyFileP;
Σ = MyFileP[[1]];
Ṁ = MyFileP[[2]] 10 × 4 π G M/(c κes);
R = MyFileP[[3]] 2 G M/c^2;
(*Kinematic viscosity*)
ν = Ṁ/(3 π Σ);
(*Keplerian angular velocity*)
Ω = Sqrt[G M/R^3] ;
(*Central sound speed*)
cs0 = Sqrt[kb Tc/(μ0 mp)]

Teff = (((9/8) ν Σ) Ω^2/σ)^0.25 ;

Tss[Tc_, u_, Σ_] := Tc (1 - 4 (u/Σ)^2)^(1/4) ;
profile = Import[NotebookDirectory[] <> MyFile, "Table"];
(*Finding the points which bracket the effective temperature*)
tlow = (Position[profile[[All, 4]], x_ /; x < Teff])[[1]];
thigh = (Position[profile[[All, 4]], x_ /; x > Teff])[[-1]];
Extract[profile[[All, 1]], {thigh, tlow}]
Print["u*=", Σ/2 Sqrt[1 - 8/((3 / 2) κes Σ)] ]

u0 = profile[[All, 1]] // Min;
umax = profile[[All, 1]] // Max;
Tc = profile[[1, 4]];
t1 = Show[{profile[[All, {1, 4}]]} // ListLinePlot[#, PlotRange → All] &,
   Plot[Teff, {u, u0, umax}], PlotRange → All, AxesLabel → {"u", "T"}, AxesOrigin → {0, 0}];
t2 = Plot[Tss[Tc, u, Σ], {u, 0, umax}, PlotStyle → Directive[Red]];
Show[t1, t2]
{profile[[All, {1, 2}]]} // ListLinePlot[#, AxesLabel → {"u", "z"}, PlotRange → All] &
{profile[[All, {1, 3}]]} // ListLinePlot[#, AxesLabel → {"u", "ρ"}, PlotRange → All] &
profile[[All, {2, 4}]] //
 ListLinePlot[#, PlotRange → All, AxesOrigin → {0, 0}, PlotRange → All] &
(profile[[All, 6]] - profile[[All, 7]]) // ListLinePlot[#, AxesOrigin → {0, 0}] &
```

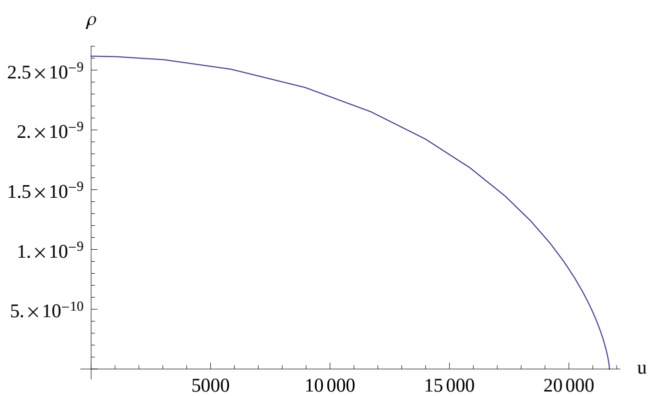
2.15535×10^{6}

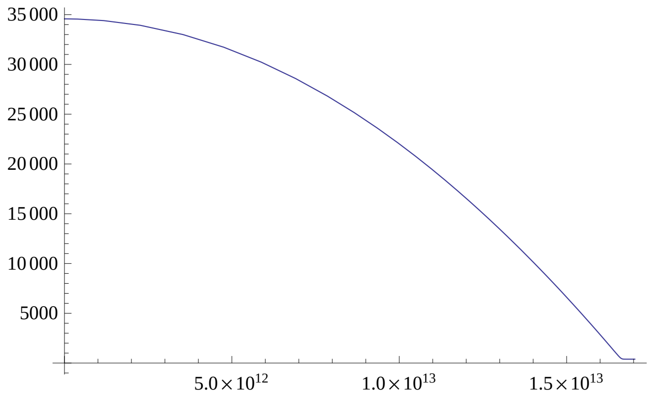
{21 694., 21 694.}

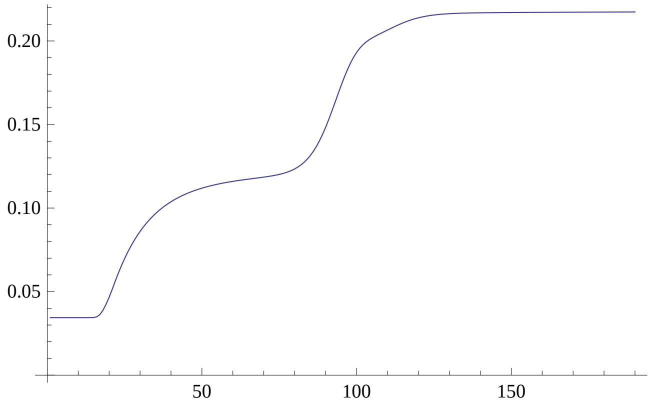
u* = 21 694.2











$$1.38\times10^{-23}\ \frac{10^{9}}{1.6\times10^{-19}}$$

86250.