In[347]:=

In[348]:=
```
Clear["Global`*"]
Needs["Notation`"]
Msun = 2 × 10^33;
Mdotsol = (Msun / (3.15 × 10^7))
G = 6.67 × 10^-8;
c = 3 × 10^10;
σ = 5.67 × 10^-5;
kb = 1.38 × 10^-16;
mp = 1.67 × 10^-24;
me = 9 × 10^-27;
κes = 0.4;

Symbolize[ Ṁ ]
Symbolize[ κ̂ ]
Symbolize[ M7 ]
Symbolize[ α0.3 ]
Symbolize[ ṁ ]
Symbolize[ ṀEdd ]
Symbolize[ LEdd ]
Symbolize[ RS ]
Symbolize[ ϵ0.1 ]

M = 10^7 Msun M7;
LEdd = 4 π G M / (0.4 μe κ̂) c

ṀEdd = LEdd / (c^2 ϵ0.1 0.1)
Ṁ = ṁ ṀEdd;
RS = 2 G M / c^2;
R = 10^3 RS r3;

Q = G M / R^3
Teff = (3 / (8 π σ) G M Ṁ / R^3)^1/4 // Simplify[#, Assumptions → {M7 > 0, r3 > 0}] &

Tc = 8 × 10^4 μ0^1/5 μe^-1/5 r3^-9/10 M7^-1/5 α0.3^-1/5 fT^1/5 (ṁ / ϵ0.1)^2/5 κ̂^1/5 ;

Σ = Ṁ / (3 π kb Tc / (μ0 mp) 0.3 α0.3) (G M7 10^7 Msun / R^3)^1/2 // Simplify[#, Assumptions → {M7 > 0, r3 > 0}] &
```

In[378]:=

In[379]:=
```
(*Compton y parameter*)
y = 4 kb Tc1/(me c^2) Max[Σ κes/2, (Σ κes/2)^2] /.
   {α0.3 → 1, μ0 → 0.615, μe → 0.875, ϵ0.1 → 1, ṁ → 0.1, κ̂ → 1, fT → 3/8} // Simplify
RegionPlot[y > 1, {M7, 0.01, 100}, {r3, 0.1 , 10}]
```

In[381]:=
```
Teff1
Q1
Σ1
```

In[404]:=
```
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}

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}}]
```