

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.00312

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.00312

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.0031

which is a local  
temperature detected  
by the free fall observer  
at the finite distance  
from the black hole in  
the thermal equilibrium  
state.

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.00312

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.00312

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.00312

# A quantal Tolman temperature

Yongwan Gim  
(Sogang University, Korea)

collaborated with Wontae Kim  
and based on arxiv : 1508.00312

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_\mu T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^\mu u^\nu + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^\mu_\mu = 0$	
Stefan-Boltzmann law	$\rho = \gamma T^2$  $p = \gamma T^2$	
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ $\frac{C_0}{\sqrt{\gamma}}$ : Hawking temperature	



	<b>Old Tolman Temperature</b> [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ <p><math>\frac{C_0}{\sqrt{\gamma}}</math> : Hawking temperature</p>	

	<b>Old Tolman Temperature</b> [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ $\frac{C_0}{\sqrt{\gamma}}$ : Hawking temperature	

	<b>Old Tolman Temperature</b> [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ $\frac{C_0}{\sqrt{\gamma}}$ : Hawking temperature	

	<b>Old Tolman Temperature</b> [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	
Proper temperature	<div> <math display="block">T = \frac{C_0}{\sqrt{\gamma f(r)}}</math> </div> $\frac{C_0}{\sqrt{\gamma}}$ : Hawking temperature	

	<b>Old Tolman Temperature</b> [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ <div> <math>\frac{C_0}{\sqrt{\gamma}}</math> : Hawking temperature </div>	

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$ ?	
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ $\frac{C_0}{\sqrt{\gamma}}$ : Hawking temperature	

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	$T^{\mu}_{\mu} \neq 0 \quad \text{ex) } T^{\mu}_{\nu} \sim R$
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	$\rho = \gamma T^2 - \frac{1}{2}T^{\mu}_{\mu}$ $p = \gamma T^2 + \frac{1}{2}T^{\mu}_{\mu}$
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ $\frac{C_0}{\sqrt{\gamma}} : \text{ Hawking temperature}$	$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2}T^{\mu}_{\mu} + \frac{1}{2} \int T^{\mu}_{\mu} df_1}$

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	$T^{\mu}_{\mu} \neq 0$ ex) $T^{\mu}_{\nu} \sim R$
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	$\rho = \gamma T^2 - \frac{1}{2}T^{\mu}_{\mu}$ $p = \gamma T^2 + \frac{1}{2}T^{\mu}_{\mu}$
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ $\frac{C_0}{\sqrt{\gamma}}$ : Hawking temperature	$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2}T^{\mu}_{\mu} + \frac{1}{2} \int T^{\mu}_{\mu} df_1}$



	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
Conservation law	$\nabla_\mu T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^\mu u^\nu + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^\mu_\mu = 0$	$T^\mu_\mu \neq 0$ ex) $T^\mu_\nu \sim R$
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	<div> <math display="block">\rho = \gamma T^2 - \frac{1}{2}T^\mu_\mu</math> <math display="block">p = \gamma T^2 + \frac{1}{2}T^\mu_\mu</math> </div>
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ <p><math>\frac{C_0}{\sqrt{\gamma}}</math> : Hawking temperature</p>	$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2}T^\mu_\mu + \frac{1}{2} \int T^\mu_\mu df_1}$

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	$T^{\mu}_{\mu} \neq 0 \quad \text{ex) } T^{\mu}_{\nu} \sim R$
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	$\rho = \gamma T^2 - \frac{1}{2}T^{\mu}_{\mu}$ $p = \gamma T^2 + \frac{1}{2}T^{\mu}_{\mu}$
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ <p><math>\frac{C_0}{\sqrt{\gamma}}</math> : Hawking temperature</p>	<div> <math display="block">T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2}T^{\mu}_{\mu} + \frac{1}{2} \int T^{\mu}_{\mu} df_1}</math> </div>

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
Conservation law	$\nabla_{\mu} T^{\mu\nu} = 0$	
Perfect fluid	$T^{\mu\nu} = (\rho + p)u^{\mu}u^{\nu} + pg^{\mu\nu}$	
The first law	$dU = TdS - pdV$	
Trace anomaly	$T^{\mu}_{\mu} = 0$	$T^{\mu}_{\mu} \neq 0 \quad \text{ex) } T^{\mu}_{\nu} \sim R$
Stefan-Boltzmann law	$\rho = \gamma T^2$ $p = \gamma T^2$	$\rho = \gamma T^2 - \frac{1}{2}T^{\mu}_{\mu}$ $p = \gamma T^2 + \frac{1}{2}T^{\mu}_{\mu}$
Proper temperature	$T = \frac{C_0}{\sqrt{\gamma f(r)}}$ <p><math>\frac{C_0}{\sqrt{\gamma}}</math> : Hawking temperature</p>	$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2}T^{\mu}_{\mu} + \frac{1}{2} \int T^{\mu}_{\mu} df_1}$

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph		

Old Tolman Temperature  
[R.C.Tolman,Phys.Rev.35,904(1930)]

New quantal Tolman Temperature

2D Schwarzschild  
black hole

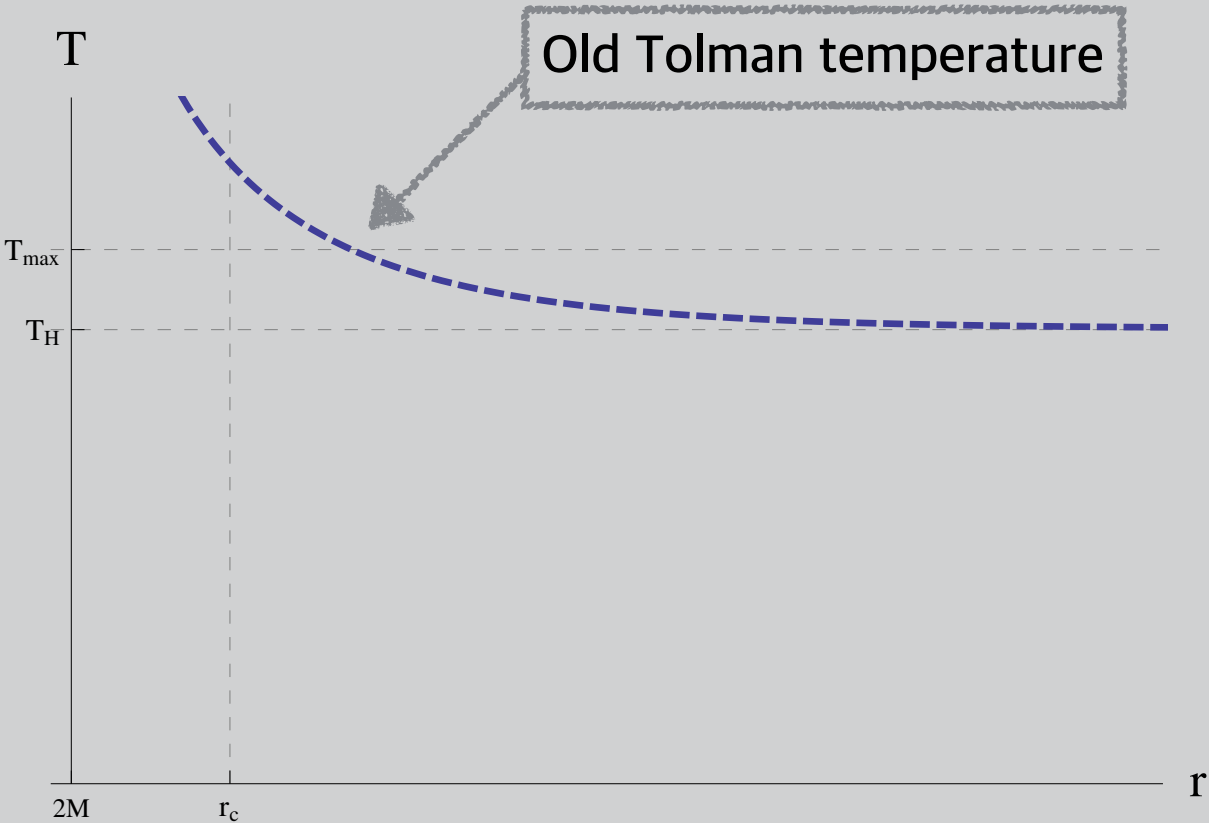
$$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$$

Proper  
temperature

$$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$$

$$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$$

Graph



	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi G M \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph		

Old Tolman Temperature  
[R.C.Tolman,Phys.Rev.35,904(1930)]

New quantal Tolman Temperature

2D Schwarzschild  
black hole

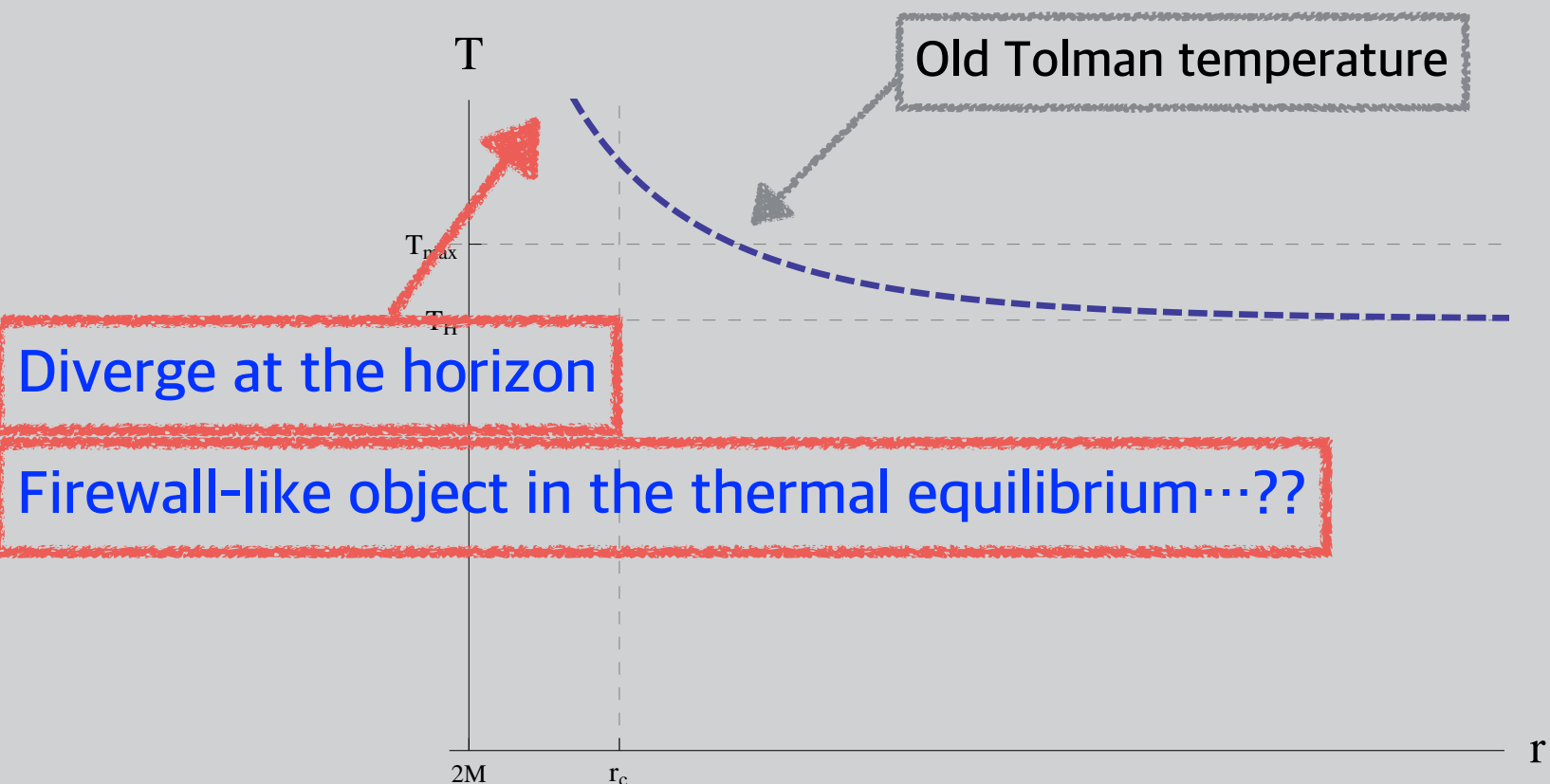
$$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$$

Proper  
temperature

$$T = \frac{1}{8\pi G M \sqrt{1 - \frac{2M}{r}}}$$

$$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$$

Graph



	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi G M \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph	<p>Diverge at the horizon</p> <p>Firewall-like object in the thermal equilibrium...??</p> <p>Violation of the equivalence principle...??</p>	



	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph	<p>Diverge at the horizon</p> <p>Firewall-like object in the thermal equilibrium...??</p> <p>Violation of the equivalence principle...??</p> <p>Old Tolman temperature</p>	

Old Tolman Temperature  
[R.C.Tolman,Phys.Rev.35,904(1930)]

New quantal Tolman Temperature

2D Schwarzschild  
black hole

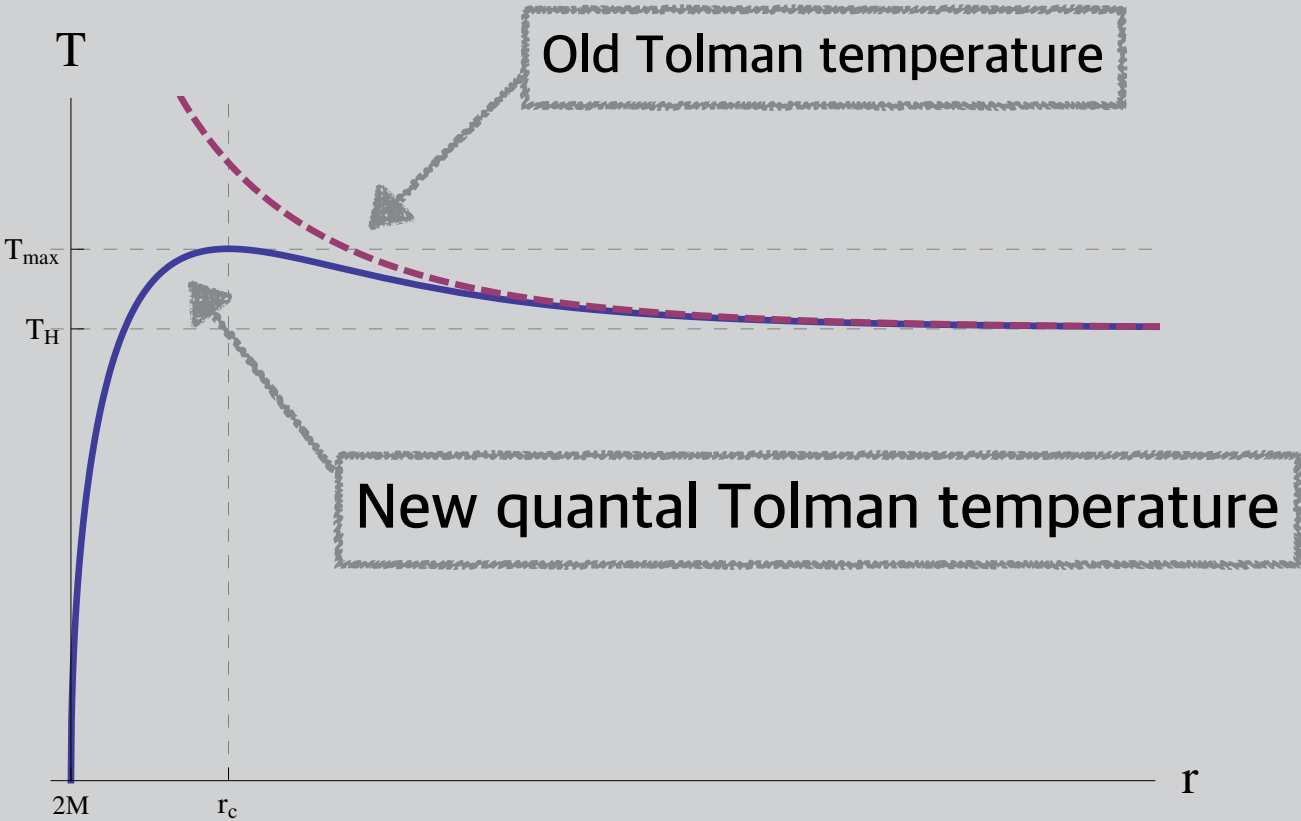
$$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$$

Proper  
temperature

$$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$$

$$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$$

Graph



	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph	<p>The graph shows the relationship between temperature <math>T</math> and radial coordinate <math>r</math> for a 2D Schwarzschild black hole. The vertical axis represents temperature <math>T</math>, with specific values <math>T_{\max}</math> and <math>T_H</math> marked. The horizontal axis represents the radial coordinate <math>r</math>, with the event horizon at <math>2M</math> and a critical radius <math>r_c</math> indicated. Two curves are plotted: the 'Old Tolman temperature' (dashed purple line) and the 'New quantal Tolman temperature' (solid blue line). The Old Tolman temperature diverges to infinity as <math>r</math> approaches <math>2M</math>. In contrast, the New quantal Tolman temperature starts at zero at the horizon (<math>r = 2M</math>), reaches a maximum <math>T_{\max}</math> at <math>r_c</math>, and then decreases, eventually matching the Old Tolman temperature at large distances. A red circle highlights the point where the new temperature vanishes at the horizon, with a red arrow pointing to it and the text 'vanish at the horizon'.</p>	

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph	<p>The graph illustrates the behavior of temperature near a 2D Schwarzschild black hole horizon. The vertical axis represents Temperature (<math>T</math>), and the horizontal axis represents the radial coordinate (<math>r</math>). The horizon is located at <math>r = 2M</math>.</p> <ul style="list-style-type: none"> <li><b>Old Tolman temperature (dashed purple line):</b> This curve starts at a high value at the horizon (<math>r = 2M</math>) and decreases monotonically as <math>r</math> increases.</li> <li><b>New quantal Tolman temperature (solid blue line):</b> This curve starts at zero at the horizon (<math>r = 2M</math>), reaches a maximum value <math>T_{\max}</math> at a critical radius <math>r_c</math>, and then decreases, asymptotically approaching the Old Tolman temperature at large <math>r</math>.</li> <li><b>Annotations:</b> <ul style="list-style-type: none"> <li><b>vanish at the horizon:</b> Points to the origin of the New quantal Tolman temperature curve at <math>(2M, 0)</math>.</li> <li><b>Nothing at the horizon:</b> Points to the Old Tolman temperature curve at the horizon.</li> </ul> </li> </ul>	

	Old Tolman Temperature [R.C.Tolman,Phys.Rev.35,904(1930)]	New quantal Tolman Temperature
2D Schwarzschild black hole	$ds^2 = - \left( 1 - \frac{2M}{r} \right) dt^2 + \frac{1}{1 - \frac{2M}{r}} dr^2$	
Proper temperature	$T = \frac{1}{8\pi GM \sqrt{1 - \frac{2M}{r}}}$	$T = \frac{1}{8\pi M} \sqrt{1 + \frac{2M}{r} + \left( \frac{2M}{r} \right)^2 - 3 \left( \frac{2M}{r} \right)^3}$
Graph	<p>vanish at the horizon    Nothing at the horizon</p> <p>Equivalence principle is recovered.</p>	

## Conclusions and Discussions

$$\rho = \gamma T^2 - \frac{1}{2} T_{\mu}^{\mu} \quad p = \gamma T^2 + \frac{1}{2} T_{\mu}^{\mu}$$

Modified  
Stefan-  
Boltzmann law

Stefan-Boltzmann law should be modified with the trace of the energy-momentum tensor. So, when we calculate the temperature, we should use this modified Stefan-Boltzmann law.

ex) Hawking radiation, Cosmology etc...

$$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2} T_{\mu}^{\mu} + \frac{1}{2} \int T_{\mu}^{\mu} df_1}$$

A quantal  
Tolman  
temperature

Thanks to this formula, the temperature vanishes when the observer arrives at the horizon. Therefore, there does not exist firewall-like object in the thermal equilibrium of the blackhole system, and the equivalence principle is recovered at the horizon.

## Conclusions and Discussions

$$\rho = \gamma T^2 - \frac{1}{2} T_{\mu}^{\mu} \quad p = \gamma T^2 + \frac{1}{2} T_{\mu}^{\mu}$$

Modified  
Stefan-  
Boltzmann law

Stefan-Boltzmann law should be modified with the trace of the energy-momentum tensor. So, when we calculate the temperature, we should use this modified Stefan-Boltzmann law.

ex) Hawking radiation, Cosmology etc...

$$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2} T_{\mu}^{\mu} + \frac{1}{2} \int T_{\mu}^{\mu} df_1}$$

A quantal  
Tolman  
temperature

Thanks to this formula, the temperature vanishes when the observer arrives at the horizon. Therefore, there does not exist firewall-like object in the thermal equilibrium of the blackhole system, and the equivalence principle is recovered at the horizon.

## Conclusions and Discussions

$$\rho = \gamma T^2 - \frac{1}{2} T_{\mu}^{\mu} \quad p = \gamma T^2 + \frac{1}{2} T_{\mu}^{\mu}$$

Modified  
Stefan-  
Boltzmann law

Stefan-Boltzmann law should be modified with the trace of the energy-momentum tensor. So, when we calculate the temperature, we should use this modified Stefan-Boltzmann law.

ex) Hawking radiation, Cosmology etc...

$$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2} T_{\mu}^{\mu} + \frac{1}{2} \int T_{\mu}^{\mu} df_1}$$

A quantal  
Tolman  
temperature

Thanks to this formula, the temperature vanishes when the observer arrives at the horizon. Therefore, there does not exist firewall-like object in the thermal equilibrium of the blackhole system, and the equivalence principle is recovered at the horizon.



## Conclusions and Discussions

$$\rho = \gamma T^2 - \frac{1}{2} T_{\mu}^{\mu} \quad p = \gamma T^2 + \frac{1}{2} T_{\mu}^{\mu}$$

Modified  
Stefan-  
Boltzmann law

Stefan-Boltzmann law should be modified with the trace of the energy-momentum tensor. So, when we calculate the temperature, we should use this modified Stefan-

**Thank you for your attention!!**

$$T = \frac{1}{\sqrt{\gamma f}} \sqrt{C_0 - \frac{f}{2} T_{\mu}^{\mu} + \frac{1}{2} \int T_{\mu}^{\mu} df_1}$$

A quantal  
Tolman  
temperature

Thanks to this formula, the temperature vanishes when the observer arrives at the horizon. Therefore, there does not exist firewall-like object in the thermal equilibrium of the blackhole system, and the equivalence principle is recovered at the horizon.