Is the threshold curvature that corresponds to the onset of the uselessness of mass-energy for work a variable measure?

S. Halayka *

January 6, 2012

Abstract

A duality between entropy and curvature is discussed.

1 Discussion

According to the laws of black hole thermodynamics and the holographic principle [1–4], the activity of the quantum fields at the event horizon radius

$$R_{\text{bh}} = \frac{2GM}{c^2} \tag{1}$$

of a Schwarzschild black hole over some macroscopic period time corresponds to an entropy of

$$S_{\text{bh}} = \frac{A_{\text{bh}}}{4\ell_p^2}, \tag{2}$$

where

$$A_{\text{bh}} = 4\pi R_{\text{bh}}^2. \tag{3}$$

In terms of information theory, it takes S_{bh} natural units of information to encode the $e^{S_{\text{bh}}}$ distinct microstates that are formed by the activity of the quantum fields at R_{bh}.

The black hole entropy S_{bh} is the maximal entropy that this given amount of mass-energy M can possess, and if M were to be in the form of every day material instead (ie. a car), then the entropy S of M would surely be less than the maximum S_{bh}. The black hole entropy S_{bh} also corresponds to a threshold where this given amount of mass-energy M becomes unusable for work.

Dividing the black hole's entropy by the black hole's event horizon area provides a measure of curvature

$$\kappa_{\text{bh}} = \frac{S_{\text{bh}}}{A_{\text{bh}}} = \frac{1}{4\ell_p^2} \tag{4}$$

that is common to all Schwarzschild black holes. It is important to stress that this measure of curvature corresponds to the threshold where mass-energy is hidden behind a black hole event horizon, and to stress that this curvature threshold is dual to the aforementioned entropy threshold where mass-energy becomes unusable for work. From this we may conclude that being behind an event horizon and being unusable for work are analogous circumstances.

The quantum fields outside of the event horizon are also active, to a lesser extent, and some of this activity eventually leads to and corresponds to photons that escape the black hole's gravitation, which causes the black hole to leak both energy and entropy. It is important to stress that these photons that do escape the black hole's gravitation remain unusable for work, because if these photons were to spontaneously become usable for work then this would lead to a forbidden breakdown in the second law of general thermodynamics $dS/dt \geq 0$. From this we may conclude that these unusable photons produce a sort of dark background that fills the black hole exterior.

*Little Red River Park, SK Canada – email: shalayka@gmail.com

The quantum field activity corresponding to these unusable photons at some distant shell of radius

$$R_{\text{shell}} \gg R_{\text{bh}}, \tag{5}$$

$$A_{\text{shell}} = 4\pi R_{\text{shell}}^2 \gg A_{\text{bh}} \tag{6}$$

over some macroscopic period of time corresponds to some non-zero entropy S_{shell}. Since this distant shell does not correspond to the black hole event horizon by definition, the measure of curvature

$$\kappa_{\text{shell}} = \frac{S_{\text{shell}}}{A_{\text{shell}}} \tag{7}$$

will be less than the maximum of $\kappa_{\text{bh}} = 1/(4\ell_p^2)$.

May we infer that, similar to the entropy-curvature threshold duality at the black hole event horizon, this (non-maximum) curvature κ_{shell} formed by these unusable photons thus defines a sort of local (non-maximum) threshold where a small test mass-energy M_{test} of sufficient (but non-maximum) curvature

$$\kappa_{\text{test}} = \frac{S_{\text{test}}}{4\pi\left(\frac{2GM_{\text{test}}}{c^2}\right)^2} \geq \kappa_{\text{shell}}, \tag{8}$$

would become unusable for work because M_{test} would become hidden behind a sort of event horizon?

Is such an unusable photon background generated by a galaxy, and if so, could this background possibly be the *raison d'être* for the dark matter particles that are commonly thought to produce the non-Newtonian nature of the galactic rotation curves? Likewise, is such an unusable photon background generated by the Earth, and if so, could this background possibly explain the non-observation of cosmic rays with ultra high energies above the GZK threshold? In other words, could it possibly be that individual dark matter particles and individual ultra high energy cosmic rays each possess too much entropy to be usable for work (as defined locally by κ_{shell}), even though none of these individual particles are black holes in the traditional sense?

References

[1] 't Hooft G. Dimensional reduction in quantum gravity. (1993) arXiv:gr-qc/9310026v2

[2] Susskind L. The world as a hologram. (1994) arXiv:hep-th/9409089v2

[3] Bigatti D, Susskind L. TASI lectures on the holographic principle. (1999) arXiv:hep-th/0002044v1

[4] 't Hooft G. The holographic principle. (2000) arXiv:hep-th/0003004v2