Black Hole Thermodynamic References

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The recent success concerning black holes and the most famous living physicist Stephen Hawking is reason enough to have some interest in the field of black hole thermodynamics. A unification of thermodynamics and black hole physics began when Hawking discovered something unique about the surface area of a black hole. He realized that the surface area of a black hole always increases. This is very reminiscent of something in thermodynamics that also 'always increases'. A postgraduate student of John Wheeler, (the physicist who coined the term "black hole") Jacob Bekenstein, wrote a paper about how he thought a black hole has entropy and that its entropy is the same as its surface area. This inspired Hawking to continue with what thermodynamics says about objects with entropy. Hawking asserted that because a black hole has entropy, it has a temperature, and if it has a temperature, it must give off thermal radiation. Hawking discovered that black holes are not black. He discovered they emit radiation, something that used to define what a black hole was. It used to widely assumed that a black hole was an object that emits no radiation. His mechanism for doing this was to unite thermodynamics, black hole physics(general relativity) and quantum mechanics into one description of how black holes radiate. His use of the uncertainty principle and virtual particles to explain how black holes emit radiation is fascinating, but for this reference I'll stick with sources for just the thermodynamical unification.

The main ideas are:

$$S = c_1 A$$

Where S is entropy, c_1 is a constant and A is the surface area of black hole.

$$T = c_2 G$$

where T is the temperature, c_2 is a constant, and G is the surface gravity of the black hole.

The best sources for the study of the thermodynamics of black holes that I recommend, would be pretty much anything written by Robert Wald. He seems to be the leading teacher of this area of physics, and has written about this subject extensively. The places to find good introduction to this topic are in introductive general relativity books, particularly Wald's *General Relativity* and Schutz's *A first course in general relativity.* A very easy and fun to read book, and international bestseller, summarizes Hawking's discoveries and work: *Introducing Stephen Hawking* by J.P. McEvoy and Oscar Zarate. It has a comic book feel to it, with a historical approach to the physics of relativistic cosmology. It can be read in a few hours. Obviously publications by Hawking and Bekenstein would be of interest.

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References

[1] Wald, Robert M. The Thermodynamics of Black Holes.
http://www.livingreviews.org/Articles/Volume4/2001-6wald

[2] Wald, Robert M. *General Relativity*. University of Chicago Press, 1984.
Robert Wald's papers on the thermodynamics of black holes can be found at this url:
http://arxiv.org/find/gr-qc/1/au:+wald/0/1/0/all/0/1

[3] McEvoy, J.P. and Oscar Zarate, *Introducing Stephen Hawking*. Icon Books, 1999.

[4] Bernard F. Schutz, *A First Course in General Relativity*, Cambridge University Press, Cambridge, 1986.

[5] Jacob Bekenstein, *Black holes and entropy*, Phys. Rev. D 7:2333-2346 1973.
Jacob Bekenstein's papers on the thermodynamics of black holes can be found at this url:
http://www.aeiveos.com/ bradbury/Authors/Computing/Bekenstein-JD/