

# Heat Flow as Origin of Dark Energy

Marcelo Samuel Berman

Instituto Albert Einstein/Latinamerica, Curitiba, Brazil

Email: msberman@institutoalberteinstein.org, marsambe@yahoo.com

Received July 1, 2013; revised August 3, 2013; accepted September 4, 2013

Copyright © 2013 Marcelo Samuel Berman *et al.* This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

## ABSTRACT

We first introduce entropy according to University Physics textbooks, then, briefly discuss it, and then we prove by a general relativistic derivation that the Universe has entropy growth, like a white-hole, that it is  $R^2$ -dependent, and that dark energy, represented by a cosmological “constant”, is caused by heat flow, and provides for entropy growth.

**Keywords:** Cosmology; Entropy; Dark Matter; Heat Flow; Universe

## 1. Introduction

The entropy growth in the Universe was studied by Berman [1]. Here, we re-address the problem. One of the reasons for such return to this subject is that in the latter paper, we consider the absolute temperature to be represented by the Machian temperature, the sort of thing that is problematic, so, now, we conform to standard treatises, where the absolute temperature of the Universe is identified by its radiation, rather than by its matter contents. The better result is that we find either for the Universe or for black holes, the same  $R^2$ -dependence of entropy, while in reference [1], the non-standard temperature definition, yielded, for the Universe, an entropic formula dependent on  $R^{3/2}$ . However, the main motivation of entropy study is the deficiency of Standard Cosmological theory, whereby the fluid is isentropic, nobody is willing to accept the sort of thing. The entropy of the Universe is a measure of the disorder which entails negative information, according to Claude Shannons in-terpretation in the theory of communication. Berman and Gomide [2] showed that the Universe resembled a Kerr white-hole. Here, we just show that the formula for entropy of the Universe is the same as for a white-hole, *i.e.*, varies with the square of the radius. Then we delve into dark energy considerations showing its physical origin, as heat flow in the Universe.

## 2. Entropy in Physics Textbooks

Berman[3] has shown, by pseudotensors, that the total energy of the Universe, is constant zero.

From Thermodynamics, the entropy of a reversible

process, is given by [4],

$$TdS = dE_{\text{total}} + pdV$$

where  $T, S, E_{\text{total}}$ , and  $p, V$  stand for absolute temperature, entropy, total energy, pressure and volume.

For Cosmology, one conveys the absolute temperature, as the one for radiation. So, we write, for cosmology,

$$T_{\text{cosmology}} = T_{\text{rad}}$$

while, for Black-Holes, and Cosmology, we take the perfect gas equation of state,

$$p = \alpha\rho,$$

where  $\alpha = \text{constant}$ , and  $\rho$  stands for energy density.

## 3. Entropy of the Universe

According to George F.R. Ellis [5], many statements, about the nature of entropy, are wrong when gravity is dominant, as is the case in Cosmology. Such studies, he says, are ill-founded. We tried to get rid of such inconveniences, by working directly upon first principles.

As the total energy of the Universe, is constant zero, we find,

$$dS = 4\pi\alpha\rho T_{\text{rad}} R^2 dR$$

On the other hand, Machian analyses make the energy density dependent on  $R^{-2}$ , in accordance with Berman [6,7]. The Machian theory, includes the zero-total energy theorem, and includes Brans-Dicke relation, which we take as exact.

From the energy statement,

$$E = Mc^2 - GM^2/2R = 0$$

we find,

$$\frac{GM}{c^2 R} \approx 1$$

Then, the energy density, say, of the mass, is given by,

$$\rho = \frac{Mc^2}{(4/3)\pi R^3} \approx \frac{3c^4}{4\pi GR^2} \propto R^{-2}$$

thus proving our previous assertion.

Then, we have,

$$dS = 4\pi\alpha\rho_0 T_{\text{rad}} dR$$

where  $\rho_0$  is a constant.

Still, the radiation law is, for a black body,

$$\rho_{\text{rad}} = aT_{\text{rad}}^4 = \rho_{00}R^{-4}$$

where  $\rho_{00}$  is constant, in accordance with any Cosmology textbook [8].

Thus,

$$T_{\text{rad}} R = \text{constant}$$

Then, we find,

$$dS = S_{oo} R dR$$

or, upon integration,

$$S = S_0 R^2$$

with  $S_o$  and  $S_{oo}$  constants.

Then, the Universal entropy varies with the square of the scale-factor. The Hawking formula for Black-Holes, is also dependent on the surface of the event horizon, ie, it is also  $R^2$ -dependent [9].

#### 4. Entropy Growth with Dark Energy

In a very popular paper Berman [10], has shown that entropy growth is attained by a cosmological “constant”, that represents dark energy, and varies with cosmic time. His result, is given by formula,

$$T \frac{dS}{dt} = \dot{\rho} + 3H(\rho + p) - \gamma R^3 \dot{\lambda},$$

where the constant  $\gamma$  arises from the three-volume of the Universe, when described by,

$$V = \gamma R^3$$

On the other hand, when one deals with Raychaudhuri's equation, [11], and disconsider shear, and turn into a non-accelerating fluid, we find [12],

$$\dot{\rho} + 3H(\rho + p) + q_{,\alpha}^{\alpha} = 0$$

where  $q^{\alpha}$  stands for the heat or energy flow.

On combining all the above relations, one concludes

that the dark energy, which causes the accelerating Universe, is due to heat flow.

#### 5. Conclusion

We find that entropy grows and the Universe has a cosmological “constant” representing dark energy, which physically signifies that there is a positive heat flow in the Universe.

#### 6. Acknowledgements

MSB thanks for the important incentive offered by Miss Solange Lima Kaczyk, now a brand new advocate, continued during the last five years of his research in Cosmology.

#### REFERENCES

- [1] M. S. Berman, “Entropy Growth in the Universe,” Chapter 8,” In: J. O’Connell and A. Hale, Eds., *The Big Bang-Theory, Assumptions and Problems*, Nova Science Publishers, New York, 2012.
- [2] M. S. Berman and F. de Mello Gomide, *Journal of Modern Physics*, to be Published, 2013.
- [3] M. S. Berman, *International Journal of Theoretical Physics*, Vol. 48, 2009, pp. 3278-3286. <http://dx.doi.org/10.1007/s10773-009-0125-8>
- [4] M. S. Rogalski and S. B. Palmer, *Advanced University Physics*, 2nd Edition, Chapman, Boca Raton, 2006.
- [5] G. F. R. Ellis, “Philosophy of Physics, Part B,” In: J. Butterfield and J. Earman, Eds., *Handbook of the Philosophy of Science*, Elsevier, Amsterdam, 2007.
- [6] M. S. Berman, “General Relativity and the Pioneers Anomaly,” Nova Science Publishers, New York, 2012.
- [7] M. S. Berman, “Realization of Einsteins Machian Program,” Nova Science Publishers, New York, 2012.
- [8] S. Weinberg, “Gravitation and Cosmology,” Wiley, New York, 1972.
- [9] V. P. Frolov and I. D. Novikov, “Black Hole Physics,” Kluwer, New York, 1998. <http://dx.doi.org/10.1007/978-94-011-5139-9>
- [10] M. S. Berman, *Physical Review D*, Vol. 15, 1991, p. 1075.
- [11] A. K. Raychaudhuri, *et al.*, “General Relativity, Astrophysics, and Cosmology,” Springer Verlag, New York, 1991.
- [12] C. Barrabes and P. A. Hogan, “Advanced General Relativity,” Oxford University Press, Oxford, 2013.