Abstract Submitted
for the APR17 Meeting of
The American Physical Society

Invariant Laws of Thermodynamics and Validity of Hasenöhrl Mass-Energy Equivalence Formula m = (4/3) $E/\mathbf{c}^2$ at Photonic, Electrodynamic, and Cosmic Scales SIAVASH SOHRAB, Northwestern University —

According to a scale-invariant statistical theory of fields[1] electromagnetic photon mass is given as $m_{em,k} = \sqrt{hk/c^3}$. Since electromagnetic energy of photon is identified as $amu = \sqrt{hkc}$, all baryonic matter is composed of light (photons) $E_{em} = Nm_{em,k}c^2 = M_{em,k}c^2\,[Joule]$ or equivalently $M_{em,k}c^2/8338\,[kcal] = Namu = M_a[kg]$ where 8338 is De Pretto number[1]. Besides particle *electromagnetic* energy one requires *potential energy* associated with Poincaré [2] stress for particle stability leading to rest enthalpy[1] $\hat{h}_o = \hat{u}_o + p_o\hat{v} = \hat{u}_o + \hat{u}_o/3 = (4/3)m_{em,k}c^2$ in accordance with Hasenöhrl[3]. The 4/3 problem of electrodynamics (Boyer, T. H., Phys. Rev. Lett. **25**, 1982) is also related to Poincaré [2] stress thus the potential energy$p_o\hat{v} = \hat{u}_o/3$. Hence, the factor 4/3 is identified as Poisson polytropic index $b = c_p/c_v$ and total particle rest mass will be composed of *electromagnetic* and *gravitational* parts $m_o = m_{em} + m_{gr} = (3/4)E_o/c^2 + (1/4)E_o/c^2$. At cosmological scale, respectively 3/4 and 1/4 of the total mass of closed universe will be electromagnetic (*dark energy*) and gravitational (*dark matter*)[1] in nature as was emphasized by Pauli (*Theory of Relativity*, Dover, 1958). Also, Poincaré-Lorentz *dynamic* versus Einstein *kinematic* theory of relativity will be discussed.

[1] Sohrab, S. H., *ASME J. Energy Resources and Technology* **138**: 1-12 (2016). [2] Poincaré, H., *Rend. del Circ. Mat. Palermo* **21**: 129-176 (1906). [3] Hasenöhrl, F., *Annalen der Physik* **321**: 589-592 (1905).

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Date submitted: 07 Oct 2016