Invariant Laws of Thermodynamics and Validity of Hasenöhrl Mass-Energy Equivalence Formula $m = (4/3) E/c^2$ at Photonic, Electrodynamic, and Cosmic Scales

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According to a scale-invariant statistical theory of fields$^1$ electromagnetic photon mass is given as $m_{em,k} = \sqrt{\hbar k/c^3}$. Since electromagnetic energy of photon is identified as $amu = \sqrt{\hbar kc}$, 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] = $Namu = M_o[kg]$ 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.


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