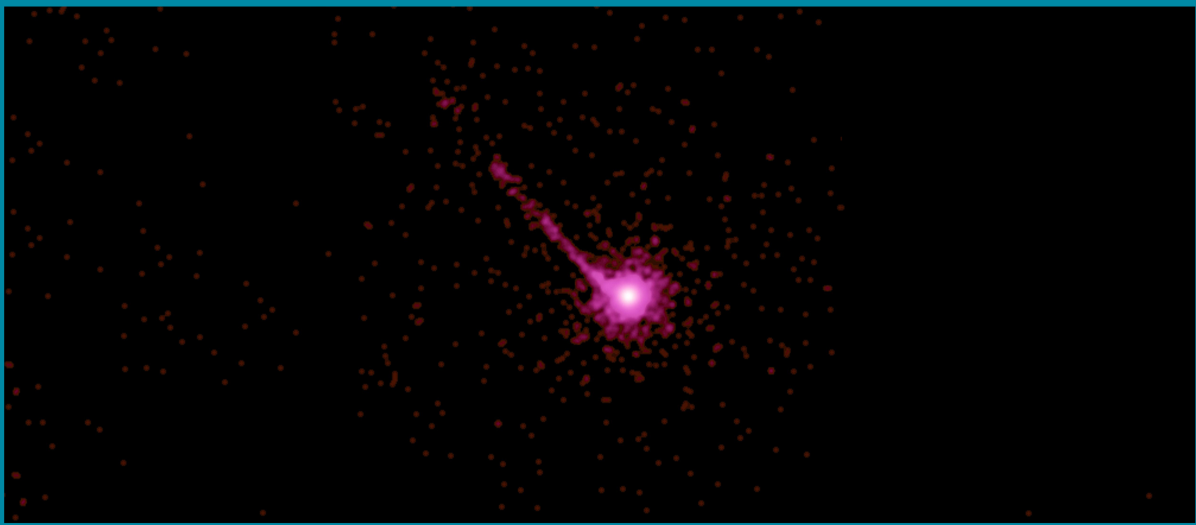
Relativistic Thermodynamics



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Title: Relativistic Thermodynamics

Author: Emil V. Veitsman

Edition: The First Edition

Published by:

Horizon Research Publishing
2880 ZANKER RD STE 203
SAN JOSE, CA 95134
USA
http://www.hrpub.org
Printed on acid-free paper

ISBN: 978-1-943484-10-2

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Email: editor@hrpub.org

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Brief Preface

Relativistic thermodynamics (RT) has been existing for more than a century, however, there are not many works in this field of physics. On the other hand, the results obtained by researchers are very contradictory. Especially it concerns the temperature transform under relativistic conditions. Why? The main explanation of the contradictions lies in the fact that the theoretical results have not been experimentally verified. Of course, it is very difficult, if possible, to perform this verification on Earth. Experiments in space are insufficient. Thus theoretical results in RT are hypothetic. However, it is much better than the absence of any theory at all. There is reason to hope that we have elaborated a consistent theory.

Acknowledgment

I express gratitude to M.L.Filchenkov for his help and councils rendered to me in writing this book.

Moscow, November, 2013 – May, 2016

Короткое предисловие

Релятивистская термодинамика (РТ) существует уже более ста лет, однако не так уже много научных работ было опубликовано более, чем за столетие, в этой области физики. С другой же стороны результаты, полученные исследователями, в высшей степени противоречивы. Особенно это касается преобразования температуры при релятивистских условиях. Почему же? С нашей точки зрения, главная причина этого заключается в отсутствии каких-либо экспериментов, осуществлённых в области релятивистской термодинамики за всё время её существования. Именно эти эксперименты могли бы подтвердить или же опровергнуть правильность результатов, полученных теоретиками. Слов нет, в земных условиях осуществить эксперименты в области РТ крайне сложно (если только вообще возможно); что же касается научной лаборатории, именуемой космосом, то ныне она освоена человечеством ещё далеко не лучшим образом. Поэтому теоретические результаты, полученные до настоящего времени, носят в основном гипотетический характер. Однако лучше какая-никакая теория, чем вообще полное отсутствие теории, особенно если она непротиворечива. Надеюсь, такая теория была мной разработана, во всяком случае, я очень надеюсь, что это именно так. Это предисловие мне хотелось бы завершить словами благодарности в адрес М.Л. Фильченкова за его помощь и советы, оказанные и данные мне по ходу написания мной этой книги, прибавив к ним цитату из Фёдора Тютчева:

«Нам не дано предугадать,

Как слово наше отзовётся…»

Москва, ноября 2013 – май 2016

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Short Biography

The author of this book, Emil V. Veitsman, PhD, is an engineer, inventor (ten inventions) and researcher. During the life he worked in several fields of science and technology: metallurgy, the patenting (like Albert Einstein), thermodynamics of irreversible processes, standardization, electronics production, theory of capillarity and, at last, relativistic thermodynamics (once more like Einstein), He is an author of more than hundred scientific articles. In 1968, as engineer-metallurgist, he has defended dissertation in the field of the continuous steel production. In 1989 he has published the book (with V.D. Venbrin, the coauthor) “The Technological Preparation of the Production of the Radio-Electronic Apparatus” (in Russian). In 1999 E.V. Veitsman releases the monograph from the field of capillarity “The Quasiton Theory in the Interface and its Application” (in Russian and English) where, using Maxwell’s ideas, represents the original theory of the interface. In particular, he studies the surface tension – the important thermodynamical parameter which anybody has not researched up to him under relativistic conditions. E.V. Veitsman decided to solve the problem connected with the relativistic surface tension having begun to work in the field of Relativistic thermodynamics where there was no any clarity already almost century. He has made an attempt to input this clarity into relativistic thermodynamics, first, having studied carefully the big part of the works concerning relativistic thermodynamics; second, having studied processes which anybody has not researched up to him under relativistic conditions – the surface tension (the above mentioned), chemical reactions and so on; third, having studied these processes in aggregate. As a result this book was born – the first monograph in the world in the field of relativistic thermodynamics.

Now Emil V. Veitsman is an independent researcher. He is also a poet and writer (fantastic short stories).

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Symbols

A (A_0) is the work; here and below symbol "0" denotes that the quantity is taken at rest.

A is the current intensity (A; §5.5)

A_r is the affinity according to De Donde.

a is a constant in (2.1.26) (J · cm^{-3}· grad^{-4}).

$a_i, a_{ik}, a_{...}$ are phenomenological coefficients.

$B_x, B_{y,} B_z$ are the tensor components of the magnetic field intensity (A·m^{-1}).

B is the magnetic induction (g$^{1/2}$ · cm$^{-1/2}$ · s^{-1} in Gaussian system of units).

C_υ is the specific heat capacity at a constant volume.

$C_{...}^{(...)}$ are correlation coefficients.

c (c) is the velocity (speed) of light.

c_k is the substance *'k'* density (mol · cm^{-3}, g · cm^{-3}).

D_{ij} is the diffusion coefficient (cm^2 · s^{-1}; tensor).

$D_{ij}^{(\lambda)}$ is the so-called thermal diffusion coefficient (cm^2 · s^{-1}; tensor).

D is the electrostatic induction (g$^{1/2}$ · cm$^{-1/2}$ · s^{-1} in Gaussian system of units).

E is the energy of system.

$\overline{E}$ is the average energy of the perfect gas.

$E_x, E_{y,} E_z$ are the tensor components of the electrical field intensity (V · m^{-1}).

E_β is the covariant 4-electrical intensity (affine tensors).

F is the free energy.

$F^{\alpha\beta}$ is the electromagnetic field tensor $\alpha, \beta = 0,1,2,3$ or $\alpha, \beta = 1,2,3,4$.

$F^{\alpha\beta}$ is the antisymmetric tensor of the electromagnetic intensity (m$^{1/2}$· cm$^{-1/2}$· s$^{-1/2}$, §5.4).

$\mathfrak{F}$ is Faraday's constant (C · mol^{-1}).

$\tilde{G}$ is the free enthalpy.

G is the momentum (vector); G is its absolute value.

$\mathbf{G}_\omega = \delta\mathbf{G}/\delta\omega$.

G, G_β are the electric intensity (J• m• C^{-1}); in Gaussian system of units – g$^{1/2}$• cm$^{-1/2}$ • s^{-1}.

$g^{\alpha\beta}, g_{\alpha\beta}$ are the fundamental tensors (contravariant and covariant).

g_α^α is the trace of $g^{\alpha\beta}$.

H is the enthalpy.

$H_\omega = \delta H / \delta\omega$ (J • cm^{-2}).

H is the magnetic field intensity (C•m^{-1}• s^{-1}); in Gaussian system of units – g$^{1/2}$• **c**m$^{-1/2}$ • s^{-1}.

$\hbar$ is Planck's reduced constant.

I is the current intensity (g$^{1/2}$ · cm$^{3/2}$ · s^{-2}; Gaussian system of units)

I_i is the amount of impurity passing per unit time through

a unit surface area perpendicular to the mass flow (mole · cm^{-2}• s^{-1}).

$I_{...}^{(...)}$ are the generalized fluxes of the type *r*, *q*, *i*, *p*, i.e., for chemical reactions, heat-, mass-, and momentum transfer.

$I_i^{(\lambda)}$ is the amount of heat passing per unit time through a unit area of surface perpendicular to the heat flux vector (J · c^{-2}• s^{-1}),

j is the three dimensional density current (C · c^{-2}• s^{-1}).

$\mathbf{i}^\alpha$ and $\mathbf{i}_\beta$ are contravariant and covariant dimensionless unit-vectors.

i is the imaginary unity.

j_α is the vector of the electric current density (g $^{1/2}$ · c$^{-1/2}$ · s^{-2}; 3-D formalism).

$\boldsymbol{J}_\alpha$ is the vector of the electric current density (4-D formalism).

j_L^0 is the current density (C · s^{-2}; g $^{1/2}$ · c$^{-1/2}$ · s^{-2}) under normal conditions.

$\mathbf{J}_Q$ is the generalized flux of heat transfer (J · **c**m^{-2} · s^{-1}).

$_v\mathbf{J}_k$ is the generalized flux of mass transfer of kind "*k*" microparticles (g · **c**m^{-2} · s^{-1}) in the system of the mass centre;

K is the force according to von Laue (see (2.2.25)).

k is the wave vector (cm^{-1}).

k is the module of the wave vector (cm^{-1}; § 3.1).

k is the Boltzmann constant (J · grad^{-1}).

k is the reaction rate coefficient (chapter 4).

$m^{\alpha(\beta)}$ is the mass-density dimensional contravariant vector (g · cm^{-3}).

L is the cube edge (cm).

$l(l_0)$ is the object length.

$M(M_0)$ is the mass of the microparticle system.

M is the magnetic polarization (J · s · C^{-1} · cm^{-2}); in Gaussian system of units – g$^{1/2}$ · cm$^{-1/2}$ · s^{-1}.

$m_i(m_{0i})$ is the mass of the microparticle of a kind "*i*".

N is the number of molecules.

N_i is the number of microparticles in the system being in the state "i", i=1,2,3,…,r .

N_X, N_Y, N_Z, N_4 are the components of the photon 4-vector (formula (2.4.5)).

n is the number of substance moles.

n is the refractory index (§5.5)

$\overline{n_i}$ is the average number of light quanta being in the state with a given energy ε_i.

n is the spatial unit vector.

P is the electric polarization (C · m^{-2}); in Gaussian system of units – g$^{1/2}$ · cm$^{-1/2}$ · s^{-1}.

p is the baric pressure and the pressure of light (N · cm $^{-2}$).

$p(x)$ is the probability distribution of *x*.

$Q(Q_0)$ is heat.

Q^{ijk} is the tensor of heat.

q is the density of the amount of heat at the point x_j (§5.2; J · cm^{-3}).

q is the velocity of a Planckian radiator.

$\boldsymbol{q}$ is the velocity vector of the object (§1).

q^0 is the quantity of heat which is allocating in unit volume of the conductor per unit time when the conducter carries a current (J · cm^{-3} · s^{-1}; §5.5).

R is the electrical resistance (V · A^{-1}).

$r(r_0)$ is the radius of a bubble or drop.

$S(S_0)$ is the entropy.

$S_\omega = \delta S / \delta\omega$ (J · grad^{-1} · cm^{-2}).

$S(S_0)$ is the surface element.

S is the heat flux (J · cm^{-2} · s^{-1}).

s is the interval (§3.2).

$T(T_0)$ is the absolute temperature.

$T^{i\alpha\beta}$ is the tensor of temperature.

$T_b(T_{0b})$ is the boiling temperature of the liquid.

$T^{\alpha\beta}$ or T^{ik} is the energy-momentum tensor.

T is the mechanical flux of energy (J · cm^{-2} · s^{-1}).

t_{ik} are the elastic stresses.

U is the electric potential difference (V).

u=u; u' are the 3-D space components of the 4-velocity vectors in the reference frames **X** and **X**'**.**

$\bar{v}$ is the average velocity of the microperticles.

V is the volume.

v is the speed.

v is the vector of the velocity.

$\overline{v^{\alpha}}$ is the vector of the mean velocity of particles in perfect gas.

$\overline{v^1}, \overline{v^2}, \overline{v^3}$ are the components of $\overline{v^{\alpha}}$;

$\sqrt{\overline{v^2}}$ is the root-mean-square velocity of the system microparticles at its mass centre.

v_{pr} is the most probable microparticle velocity.

ΔW is the work done under the system by an external source (§2.11).

$W^{\alpha\beta}$ is the energy-momentum density tensor (erg · cm^{-3}; §5.5).

w is the object velocity in a laboratory reference frame; w_1, w_2, w_3 are its components.

w' is the object velocity for the observer being in a moving reference frame; w_1', w_2', w_3' are its components.

w is the probability of the object (a subsystem in [16]) having a parameter λ in the interval $\lambda \div \lambda + d\lambda$ owing to an external work source (§11).

$X_{...}^{(...)}$ are the generalized forces of the type *q*, *i*, *p*, i.e., for the heat-, mass-, and momentum transfer.

$\mathbf{X}_Q$ is the generalized force of heat transfer (cm^{-1}).

$\mathbf{X}_k$ are the generalized forces of mass transfer of kind "*k"* microparticles (H · g^{-1}).

z_k is the electrical valency.

$\alpha, \beta, \gamma, \delta$ are the vector and tensor indices.

α is the electric conductivity (s^{-1}; Gaussian system of units).

$\beta = \frac{v}{c}$ or $\beta = \mathbf{v}/c$.

Γ is the surface density of the substance (mol · cm^{-2}).

ΔL is the thickness of the interface (cm).

$\Delta l_{\alpha(\beta)}$ are vectors (cm).

$\Delta l'_{\alpha}$ and $\Delta l'^{\beta}$ are the covariant and contravariant paths charge passed in the moving system.

Δs is the increment of the interval (SR).

ΔV is the volume of the interface (cm^3).

$\delta_{\alpha\beta}, \delta_{\alpha}^{\beta}, \delta^{\alpha\beta}$ are the Kronecker tensors.

$\varepsilon(\varepsilon_0)$ is the specific energy of the black-body radiation (J $\cdot$ V^{-1}).

ε_{ik} are the components of the deformation tensor (%).

Φ is a voltage (g$^{1/2}$ $\cdot$ cm$^{1/2}$ $\cdot$ s^{-1}; Gaussian system of units).

ζ is the coefficient of volume viscosity (g $\cdot$ cm^{-1}$\cdot$ s^{-1}).

$\zeta^{\kappa\beta}$ is the volume viscosity tensor.

η is the coefficient of the shear viscosity (g $\cdot$ cm^{-1}$\cdot$ s^{-1})

$\Lambda_{\alpha\beta}$ is the covariant 4-tensor of the conductivity (s^{-1}).

λ is the thermal conductivity coefficient (J $\cdot$ cm^{-1} $\cdot$ s^{-1} $\cdot$ grad^{-1}).

$\mu_0 = \frac{m_0}{V_0} = \frac{\delta m_0}{\delta V_0}$ is the mass density.

$\mu(\mu_0)$ is the chemical potential (J, see §5).

$\nu_{\mathrm{A}}, \nu_{\mathrm{B}}$ are the stoichiometric coefficients of the substances A and B.

$\nu(s), \nu(0)$ are oscillation frequency of photon, as $s \neq 0$ and s=0 (see formula (3.1.17)).

з is the emissive radiation power (J $\cdot$ m^{-2} $\cdot$ s^{-1}).

$\nu_0^{(j)}$ is the photon j frequency.

$\kappa_0^{(j)}$, $\boldsymbol{\kappa}$ is the directing vector of photon j.

θ is the angle between the velocity vector $\boldsymbol{v}$ and the line connecting the observer and the device.

$\Pi^{\alpha\beta}$ is the 4-D energy tensor.

$\Theta = kT.$

ρ is the electric charge density (C · cm^{-3}; §5.5).

$\rho_1(\rho_{10}), \rho_2(\rho_{20})$ is the density of substance (mol · cm^{-3}) in the condensed phase (liquid and solid) and gaseous phase.

ρ_0 is the linear coordinate in the spherical coordinate system.

$\rho(\omega, T)$ is the energy density of oscillators (J · m^{-3}; § 3.1).

σ is Stefan's constant (J · m^{-2} · s^{-1} · grad^{-4}).

σ is the surface tension (J · m^{-2}).

σ is the electrical conductivity (cm · s^{-1}) or specific electrical conductivity (s^{-1}; §5.5).

$\sigma_{\alpha\beta}$ is the tensor of electrical conductivity.

$\sigma[s]$ is the local entropy production (J · cm^{-2} · s^{-1} · grad^{-1}).

τ_{ik} are the components of the stress tensor in accordance with theory of elasticity (N · m^{-2}, see Fig.9).

υ is part of the full volume *V*.

$\varphi(\varphi_0)$ is the polar angle (the spherical coordinate system).

Ψ is the dissipative function (J · cm^{-3} · s^{-1}).

$\psi(\psi_0)$ is the azimuth angle.

ω is the oscillation frequency

ω is the area of the interface separating liquid (solid) and gas (m^2; §2.8).

ω is a macroscopic physical quantity depending on the volume *V* and the absolute temperature *T* (§2.11).

ω is the area of the surface on which the chemical reaction is running.

Relativistic thermodynamics (RT) has been existing for more than a century, however, there are not many works in this field of physics. On the other hand, the results obtained by researchers are very contradictory. Especially it concerns the temperature transform under relativistic conditions. Why? The main explanation of the contradictions lies in the fact that the theoretical results have not been experimentally verified. Of course, it is very difficult, if possible, to perform this verification on Earth. Experiments in space are insufficient. Thus theoretical results in RT are hypothetic. However, it is much better than the absence of any theory at all. There is reason to hope that we have elaborated a consistent theory.

The author of this book, Emil V. Veitsman, PhD, is an engineer, inventor (ten inventions) and researcher. During the life he worked in several fields of science and technology: metallurgy, the patenting (like Albert Einstein), thermodynamics of irreversible processes, standardization, electronics production, theory of capillarity and, at last, relativistic thermodynamics (once more like Einstein).

ISBN 978-1-943484-10-2

9 781943 484102

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