Security and Management in Modern Civil Engineering
Volume 2, Issue 1, No. 4
Received 18 April 2023; Accepted 11 May 2023

Viscous and thermal Eulerian velocity models for electric heat generation

Lena J-T Strömberg
previously Solid Mechanics, Royal Institute of Technology, Sweden
Email: *lena_str@hotmail.com*

Abstract. Direct heat with convector radiators is reliable, but expensive due to high power consumption. The present paper concerns solutions involving new formats. Observations of heat in conjunction with electricity is cast into modelling, e.g. for a heat tube. Traveling waves that fulfil the Poisson's equation are related to the framework. Independent angular velocities are connected to matter where heat is spread. While composed with multiplication, constant solutions are obtained. Exercises, relating the formula language to applied Mathematical (Physics), are included, since useful in education as well as in management of security in Engineering.

Keywords. LED-tube, portable heater, material, temperature, parameters, qualitative results, applied mathematics, harmonic, geometry, realization success.

1. Introduction

Heat in electrical devices could be obtained at mechanical motions on various scale and geometries.

- When connected to curvature, there is at least two motions.
- The heat equation (Poisson's equation) in a part of a body consists of second spatial derives, and a time derive.
- Isotropy and spherical geometry provide a dependency on a radial coordinate.

The fundaments in (Friedmann-Einstein) Cosmology are scalar differential equations with parameters related to gravity, pressure and curvature. Then, the space is assumed as a large sphere where pressure acts, a priori, [1]. In [2], it is suggested that an angular velocity Avd, exists early in the beginning, such that motion comes before the pressure. Branches of Cosmology and Astronomy concern the fact that objects create a projected copy or mirrored image in space matter. That might cause local pressures, which then develops into shell parts, where classical and elaborated theories are used, [1, 3-5]. Here, some of these foundations will be applied to observations of heat in conjunction with electricity.

The first example is a 2.5-meter LED-tube covered with an elastomere that gets heated at lightning. Then, solutions that fulfil Poisson's equation, will be considered. Next, a certain format of angular velocity is connected to heat. Finally, mathematical exercises, pin-pointing results and useful in management of safety, are given.

2. Experimental materials; observations of a LED-tube

A LED-light-tube, that also produce heat, is seen in Figure 1. Heat production is due to the configuration of lines inside, or possibly in each led lamp. The sample is 2.5m, and while moving such a rod, an electric field is created, and showing that there is a potential to obtain more heat. The photo from suppliers on internet, indicates lightning also when wired at radius R, c.f. Figure 1.

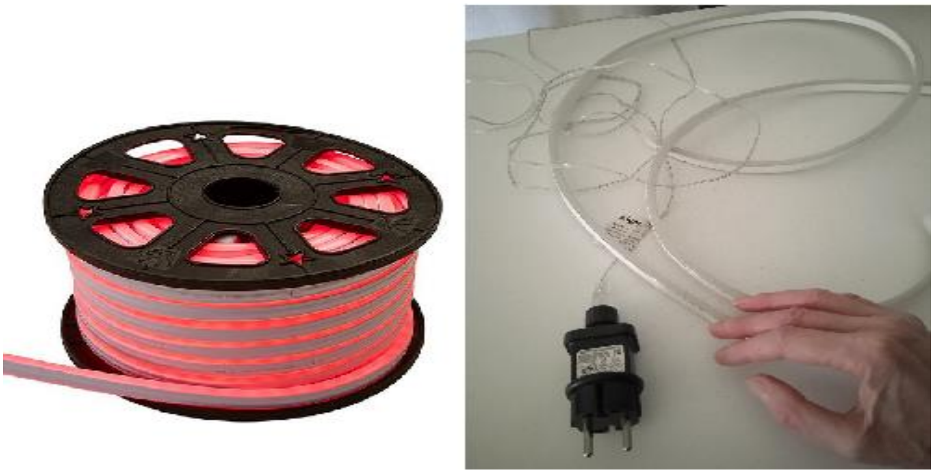

Figure 1. Left: The material for a LED-tube; (LEDs of 0.02W inside a soft elastomere). Right: A part ~2.5m and 6W, that provides enlarged temperature. At motion, it feels electric prior to desired extra heat. Possibly, additional arrangements could be done to obtain more heat from such a device

Absolute motion occurs both inside and outside. Assume that the additional detected EM-field outside depends on velocity through internal variables. To describe the behaviour of the led tube, a format of the stress tensor of a viscous fluid material will be used.

$$\mathrm{tr}\, T+3p= n\, \mathrm{tr}\, D \qquad (1)$$

where tr T is the trace of the stress tensor, p is pressure, tr D is the trace of velocity gradient and n is nonlinear viscosity. In the Lagrangian frame, this has similarities with visco-elastic materials [6, 7]. Following the model in [8], we assume that viscosity is connected to electricity and a dependency on velocity, u.

Input and Response. When moving the rod, u, $u_{,t}$ are generated as input. Also, tr D, since the material curves at motion such that air layers get contracted on one side, and elongated at the other. The pressure relates to temperature H, as $p=drH$ where d is the density and r is a material physics parameter.

If shielded with more of the same material, perhaps additional heat would develop, instead of EM.

Future experimental issues are to test the response to a curvature, when wired some laps and at motion. This could be done by comparing temperatures with the straight static, and compensate for the additional density when wired.

3. Models for velocity waves in thermo-mechanics

In fluid mechanics, the velocity $u=u(x,t)$ in Lagrangian coordinates x, at time t, may fulfil the equations of a traveling wave

$$u_{,t} + c\, u_{,x}=0 \qquad (2)$$

c.f. [8].

Assume that there are two values for c, such that also $u_{,t} - c\, u_{,x}=0$, is valid.

Remark. This can be accomplished with two kinds of linearisation for c. The same result is obtained when time changes direction. That could be a requirement, since the true situation in a flow is not classical mechanics, a priori.

With a functional format $u = \exp(.)$ on characteristics $(x-ct)/L$ or $(x+ct)/L$, solutions are given by e.g.

$$u=\exp(-ct/L) \cosh x/L \qquad (3)$$

and $$u=\exp(ct/L) \cosh x/L \qquad (4)$$

These also fulfil Poisson's equation. When temperature is the variable, it is called the heat equation, and may be derived from energy balance when input heat flux, c.f. e.g.

https://doc.freefem.org/tutorials/poisson.html .

3.1. Visualisation of temperature level

When not linearised, the wave velocity reads; $c= rHd'/d$, c.f. [8]. With $d=d_0(1+(u/u_0)^2)$, and a ratio $(u/u_0)>>1$, $c= rH2/u$.

For this case, and the solution $u = u_0\exp(-(x-ct)/L)$, the temperatures H(u,x) and H(u) are given in Figure 2 and 3. It is seen how the temperature may rise and redistribute.

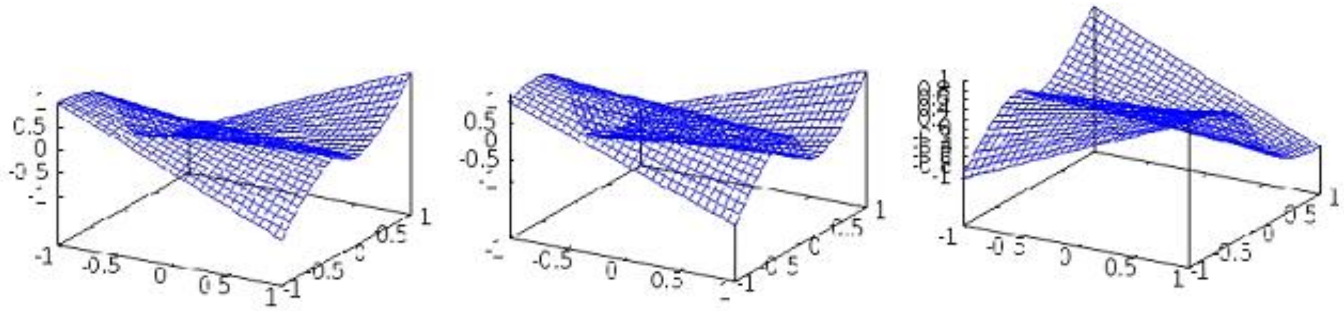

Figure 2. The temperature H(u,x) versus u and x, when c= rH(u,x)2/u and u = u0exp(-(x-ct)/L)

(Only, when the flow with velocity u, generates matter along its trajectory in directions x and perpendicular to x, the x,u-plane is connected to a real physical plane.) Values of parameters and normalisation according to the code given below. (x, used in script, is not related to the above notation) Maxima on line

```
draw3d(explicit((log(y) +x)*y,x,-1,1,y,-1,1));

draw3d(explicit((2*log(y) +x)*y,x,-1,1,y,-1,1));

draw3d(explicit((log(y) -x)*y,x,-1,1,y,-1,1));
```

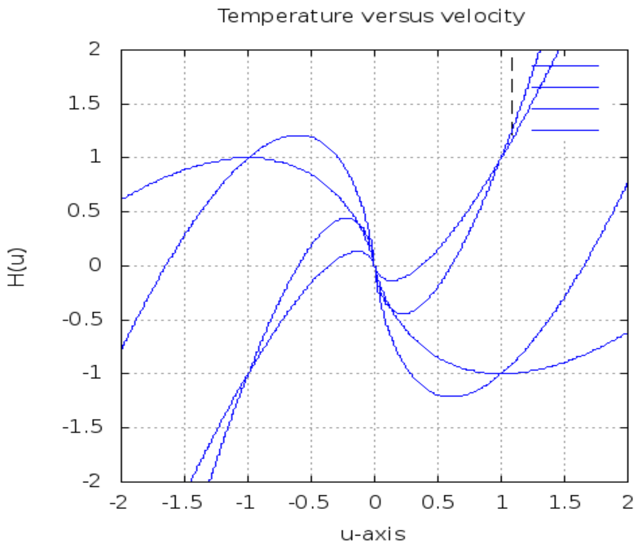

Figure 3. The temperature H(u,x) when $c= rH(u,x)2/u$ and $u = u_0\exp(-(x-ct)/L)$, versus u, for constant x, with values of parameters and normalisation given in the code given below. (x is an internal script notation) Maxima on line: http://maxima.cesga.es/

Draw2d(/* global options */ title = "Temperature versus velocity", xlabel = "u-axis", ylabel = "H(u)", grid = true, dimensions = [500,500], /* implicit function */ key = "I", implicit((log(x) -1)*x-y, x, -2,2, y, -2,2), implicit((log(x)+1)*x-y, x, -2,2, y, -2,2), implicit((2*log(x)-1)*x-y, x, -2,2, y, -2,2), implicit((2*log(x)+1)*x-y, x, -2,2, y, -2,2)).

4. Certain formats for a curved oscillating motion

From the proposal in [2], in a curved path, there is a density d and an angular velocity w that fulfil

$$wd = \text{constant} \qquad (5)$$

where

$$w(t)= w_0 \exp(-2(r_{ecc}/r_0)\sin(fw_0t)) \text{ and } d(t)= d_0 \exp(2(r_{ecc}/r_0)\sin(fw_0t)) \quad .... \qquad (6)$$

where r_{ecc}/r_0 is a ratio between radius, f is a scalar parameter and w_0 is an angular frequency and/or angular velocity.

A thermal cohomology, is that heat spreads with angular velocities w, and the density d, represents a material point. In fluid mechanics, solutions to the heat equation, are found also for the velocity u, c.f. Section 3 above. With (3) and (4), the product is time independent. If adopting the format (5) for the response to heat, also the exponentially increasing is valid. If overheat, it may arrange into a product wd, after which w and wd are the variables.

Next, some results combined with exercises in Mathematics, are deduced.

Preliminaries: For small r_{ecc}/r_0, a linearisation into

$$w=w_0(1-2(r_{ecc}/r_0)\sin(fw_0t)) \text{ and } d=d_0(1+2(r_{ecc}/r_0)\sin(fw_0t)) \qquad (7)$$

is valid. The small non-constant trigonometric parts will be denoted w1 and d1.

Exercise 1. Show that the product w1*d1 can be decomposed into a sum of a constant and a harmonic.

5. Comparison with parameter n in viscosity model

Relations between material parameters from various formulations will be obtained. They show the close relationships between viscosity, density and other geometric and kinematical variables, as well as the constant r within physical chemistry.

Poisson 's equation reads $d\, u_{,t} = -\, n\, u_{,xx}$, where n is viscosity

With the solution (3), the relation between material parameters is given by

$$cd/L=n/L^2 \qquad (8)$$

Exercise 2: A frequency has the same dimension as an angular velocity. Identify the ratio at left side in (8), with this dimension.

Solution: (c/L), since c is a velocity and L is a length.

Remark. A product between angular velocity and density is also found in equation (5).

Preliminaries: To keep Physics, i.e., not reduce variables too soon, a rescaling of coordinates may be considered.

This violates the condition of traveling waves (2); however, c was originally non-constant and may change. Then (8) reads

$$cd/l=n/L^2 \qquad (9)$$

where l is a new length parameter.

Exercise 3: Derive expressions by substituting p=drH in (8) and (9).

Exercise 4: Derive expressions by inserting c from section 3.1 in (8) and (9).

6. Concluding remarks

Some features of heat generated by electricity were addressed. The exact behaviour is a matter for testing. Predictions from nonlinear models and the existing device, Figure 1 are a promising success, (except that there need not be light from from as much as 300 LEDs if micro-twisting of the lines inside the elastomere provides the heat, alone.)

There are one-bulb lamps ~5W that also get heated, and putting some next to each other (and in front of a mirror of steel or equivalent material) might give a beneficial heat wave.

A solution with a heater built in a mirror, was presented recently in a popular science journal, c.f. infranomic.de. These are not yet astonishingly low in power, but more traditional from 400W.

In general, when curved as in Figure 1, additional heat may develop (possibly due to constrained motions for the AC-oscillations).

To connect with electrical engineering, there is need for a correspondence with EM-variables [9-14], e.g., density of loads. Then, an E-field and current, becomes the tunable variables, and to achieve a macro-heater, a capture into a quasi-static case is the goal. Possibly, this could be realised with a larger shielding of the same elastomere in a composite material version with suitable porosity and electro-heat capacity. A google-search suggests that a design like an Incandescent bulb [15-16], might be a solution, with shorter life-time, but more heat. In [17], measurments on free LED-stripes are given.

In Section 4, a model with matter and heat distribution was proposed to describe increased temperature in surrounding air. Spread of cold, may be cast in the same format. Now and then, it materialises to snowflakes and other spatial shell/wing matter.

References

[1] Souvik Banerjee, Ulf Danielsson, Giuseppe Dibitetto, Suvendu Giri, and Marjorie Schillo (2018). Emergent de Sitter Cosmology from Decaying Anti–de Sitter Space Phys. Rev. Lett. 121, 261301 – Published 27 December 2018

[2] Strömberg L, J-T (2015). Motions for systems and structures in space, described by a set denoted Avd. Theorems for local implosion; Li, dl and angular velocities. Journal of Physics and Astronomy Research. Vol. 2(3), pp. 070-073, 2015.

[3] Danielsson, U. H., Panizo, D., Tielemans, R., & Van Riet, T. (2021). Higher-dimensional view on quantum cosmology. Physical Review D, 104(8), 86015. doi:10.1103/PhysRevD.104.086015.

[4] Strömberg L J-T. (2020). Differentiations of Nonlinear Functions Related to States in Magic(n), Cosmology and the Poincare Conjecture. Journal of Human, Earth, and Future Vol. 1, No. 4, December. DOI: 10.28991/HEF-2020-01-04-05

[5] Minos Axenides, Emmanuel Floratos and Stam Nicolis (2021). The continuum limit of the modular discretization of AdS2. Corfu Summer Institute 2021 "School and Workshops on Elementary Particle Physics and Gravity" Corfu,Greece

[6] Riesen P, Hutter K, Funk M (2010). A viscoelastic Rivlin-Ericksen material model applicable to glacier ice, Nonlin. Processes Geophys., 17, 673–684. DOI: 10.5194/npg-17-673-2010.

[7] Stanisauskis E, Mashayekhia S, Paharic B, Mehnertd M, Steinmann P, Oatesc W, (2022). Fractional and Fractal Order Effects in Soft Elastomers: Strain Rate and Temperature Dependent Nonlinear Mechanics. Mechanics of Materials 172:104390.

[8] Strömberg L (2023). Response to curvature, gradients and temperature in a PPB-fuel cell, with a LED and a Li-B. Advances in Environment and Energies, Sanderman PH. Volume 2, Issue 1, No. 3.

[9] de Bem NFS, Ruppert MG, Yong YK, Fleming AJ (2020) Integrated force and displacement sensing in active microcantilevers for off-resonance tapping mode atomic force microscopy Proceedings of MARSS - International Conference on Manipulation, Automation and Robotics at Small Scales – 2020.

[10] Seethalera R, Mansoura SZ, Ruppertb MG, Fleming A (2021) A Position and force sensing using strain gauges integrated intopiezoelectric bender electrodes Elsevier. Sensors and Actuators A: Physical

[11] Xue, Zhangna & Tian, Xiaogeng & Liu, Jianlin. (2020). Hygrothermoelastic response in a hollow cylinder considering dual-phase-lag heat-moisture coupling. Zeitschrift für angewandte Mathematik und Physik. 71. DOI: 10.1007/s00033-019-1246-4.

[12] Zhang, M. H., Cao, Z. C., Xia, F. C., & Yao, Z. (2022). Structural Stiffness Matching Modeling and Active Design Approach for Multiple Stepped Cantilever Beam. International Journal of Engineering, 35(7), 1227-1236.

[13] Lock, Daren & Hall, Simon & Prins, A.D. & Crutchley, Benjamin & Kynaston, Steven & Sweeney, Stephen. (2013). LED Junction Temperature Measurement Using Generated Photocurrent. Display Technology, Journal of. 9. 396-401. DOI: 10.1109/JDT.2013.2251607.

[14] J. Rekstad, M. Meir, A.R. Kristoffersen, (2003). Control and energy metering in low temperature heating systems, Energy and Buildings, Vol 35, Issue 3, pp 281-291, ISSN 0378-7788.

[15] https://www.homebuilding.co.uk/advice/do-led-lights-get-hot

[16] https://www.any-lamp.com/blog/does-led-lights-become-warm

[17] https://www.waveformlighting.com/home-residential/how-hot-do-led-strips-get-is-it-normal