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Abstract

This is a new energy balance model for Earth, Venus and Mars, based on an equation from Planck´s book "the theory of heat radiation". The model leads to correlations between gravity and heat flow, which is supported by the discovery of a new constant for the relationship between T^4 and mass, $c^2/\sigma = 1.58510614^{24}\ K^4 * kg^{-1}$. This constant seems to have been overlooked, but is an obvious result from Einsteins $E = mc^2$, where $E = \sigma T^4$.

Planck´s energy balance

A screenshot from Planck´s book "The theory of heat radiation".

67. If, on raising the piston, the temperature of the black body forming the bottom is kept constant by a corresponding addition of heat from the heat reservoir, the process takes place isothermally. Then, along with the temperature T of the black body, the energy density u, the radiation pressure p, and the density of the entropy s also remain constant; hence the total energy of radiation increases from $U = uV$ to $U' = uV'$, the entropy from $S = sV$ to $S' = sV'$ and the heat supplied from the heat reservoir is obtained by integrating (72) at constant T,

$$Q = T(S' - S) = Ts(V' - V)$$

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or, according to (81) and (75),

$$Q = \frac{4}{3}aT^4(V' - V) = \frac{4}{3}(U' - U).$$

Thus it is seen that the heat furnished from the outside exceeds the increase in energy of radiation $(U' - U)$ by $\frac{1}{3}(U' - U)$. This excess in the added heat is necessary to do the external work accompanying the increase in the volume of radiation.

Planck describes a system with blackbody at the bottom of a cylinder that has a piston on the opposite end of the blackbody. The system is at rest, the blackbody emits radiation σT^4, and the walls of the cylinder are perfectly reflective. This means that the blackbody at the bottom is at thermal equilibrium with its surroundings, the walls reflect back the exact same amount of heat as the blackbody emits, so it can stay this way indefinitely. The system is also in mechanical equilibrium:

"An immediate consequence of this is that the pressure of the radiation on the black bottom is just as large as the oppositely directed pressure of the radiation on the reflecting piston."

Then he wants to raise the piston while keeping the temperature of the blackbody constant.

"If, on raising the piston, the temperature of the black body forming the bottom is kept constant by a corresponding addition of heat from the heat reservoir, the process takes place isothermally."

To keep the heat emission by the blackbody constant the energy supplied to the system needs to be

$$Q = \frac{4}{3}\sigma T^4 (V' - V)$$

since additional energy beyond heat emission is needed for work.

In the case of Earth, we have a steady state with constant heat flow and constant volume, but the system still does continuous work against the force of gravity, because the atmosphere circulates in a way similar way to a fountain. The work is all the atmospheric currents of mass in convection, evaporation etc, i.e. work that the surface does on its surroundings, and according to the first law this will subtract energy from the heat flow. The first law of thermodynamics applies to the system, like it does for all systems. This means that heat flow from the sun results in work being performed alongside heat emission from the surface, so I believe we can use Planck´s equation for energy balance at the Earth surface. With constant volume the term V´-V disappears, and at the surface there must be a continuous heat supply which is $\frac{4}{3}\sigma T^4$ to have constant emission at σT^4, because this system loses all the energy at the same rate as it´s absorbed. The amount of solar radiation going in at the surface must in turn be balanced to what is received at the top of the atmosphere, the tropopause, so we must take into account that we have two shells which the heat must flow through before it´s finally absorbed and emitted. Then $\left(\frac{4}{3}\right)^2 \sigma T^4$ should be the intensity of the incoming heat flow at the top of the atmosphere. This equation, starting at the surface, and following the heat flow backwards to the boundary, produces exactly the solar constant irradiating the hemisphere at $1360.9W/m^2$ with a surface temperature of 286.63K, 13.48°C, which is within 0.5°C of the average temperature of the last 8 years which is said to be the warmest on record.

$$\left(\frac{4}{3}\right)^2 4\pi r^2 \sigma T^4 = 2\pi r^2 TSI$$

Surface emission is balanced to irradiation on the whole hemisphere and some will oppose this because the greenhouse energy balance model uses only $\pi r^2 TSI$. I will stick to Planck´s equation since it works, and I don´t find the relationship unreasonable. The reduction of the heat flow with this equation is much more aggressive than in the greenhouse model which uses albedo. The reduction here is for other reasons, instead of albedo and emissivity, the entire reduction of the heat flow is categorized as work. Since Planck was describing a system with a perfect blackbody, it´s surprising that the model fits so good with Earth.

From only the solar constant we now can get the surface temperature of a system of two concentric shells:

$$\left(\frac{3}{4}\right)^2 2\pi r^2 TSI = 4\pi r^2 \sigma T^4$$

The resulting surface temperature 286.6K=13.48°C seems to fit well with, for example, P.Jones & C.Harpham and the average temperature from raw data, presented by temperature.global.

Jones&Harpham gives an interesting result for the periods 1961-1990 and 1981-2010, where it looks like the temperature didn´t increase at all.

> The absolute surface temperature of the world is likely to be between 13.7 and 14.0°C for the 1961–1990 period and 13.9 and 14.2°C for 1981–2010. The spatial detail reveals that most of this difference comes from Antarctica and to a lesser extent Greenland and the immediate coastal areas around these two landmasses. There are also large differences along the coastlines of northern Eurasia particularly in DJF. These differences are suggestive of issues over the two landmasses and their adjacent sea-ice areas, which for large parts of Antarctica makes ERA-Interim up to 10°C cooler. High-elevation areas of Antarctica are much warmer (5–6°C) than the two sites with long records. ERA-Interim, therefore, has markedly reduced temperature gradients between the interior and coastal sites than evident at the limited number of sites in eastern Antarctica.

The current temperature sits at about 14°C , it agrees very well with the result of the equation above. Small swings in average temperature over time is a fact, and it isn´t relevant for the arguments I make here.

In this system I don´t care about the details of the thermodynamic work, I just accept that a part of the heat flow is converted according to the ratio Planck gave. Just like in the first law where the change in internal energy is equal to the heat supplied minus the work done by the system, $\Delta U = Q - W$.

Also, radiation entropy is $\frac{4}{3}\sigma T^3$, so for surface emission at 286.6K the radiation entropy per kelvin is $\frac{4}{3}\sigma 286.6^3 = 1.78\ W * m^{-2} * K^{-1}$.

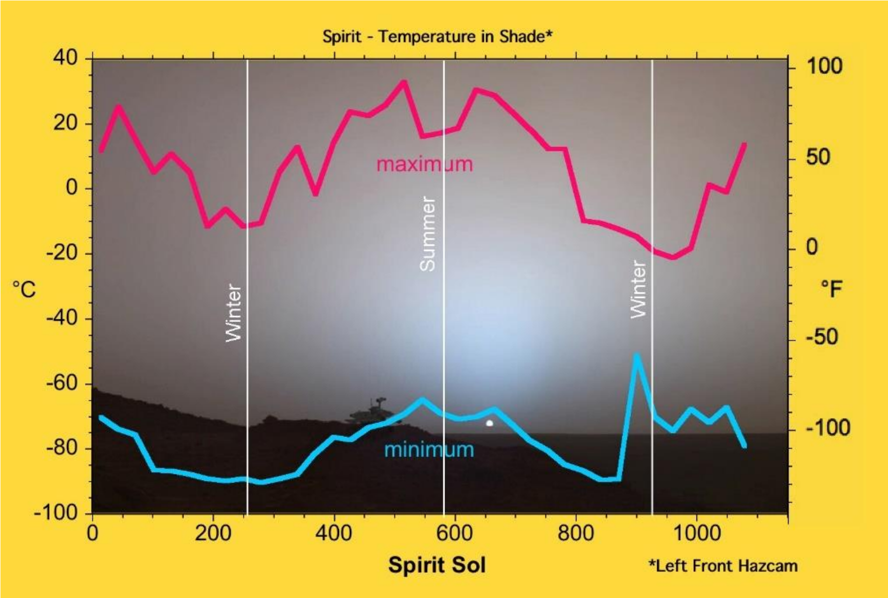
This means that the maximum energy available for work at a surface temperature of 286.6K is:

$\frac{4}{3}\sigma 286.6^3 * 286.6 - \sigma 286.6^4 = \sigma 218^4 = 127.6 W/m^2$

$127.6 W/m^2 = \sigma 218^4$ correlates to σT^4 at the tropopause which is $\sim\sigma 220^4$.

It seems like Earth behaves perfectly according to thermodynamic principles. Solar irradiation varies between $\sim 1300 - 1400 W/m^2$, and if this model is correct this should mean that we have fixed limits for a temperature range of 11-15°C. If the temperature exceeds 15°C we have an interesting mystery on our hands, which can only be explained by a change in the internal state below the surface. According to the average temperature from raw data, presented at temperature.global, which sits at this moment at ~14°C, we have a bit to go to reach the maximum.

For Venus the equation gives a temperature of 337K which corresponds to the temperature at 1 bar at 50km altitude, approximately at the base of the thick layer of clouds. Almost no heat from the sun passes down from this point to the solid surface so it would make no sense to balance sunlight to surface emission. On Mars we get a surface temperature of 232K, which seems to fit well with measurements by curiosity, even though it´s hard to say what the average surface temperature really is on Mars due to low thermometer density. Also, $\frac{(\frac{3}{4})\pi r^2 TSI}{4\pi r^2}$ gives exactly the effective emission on Mars, at 209.8K, which by some sources is given as average Mars temperature.



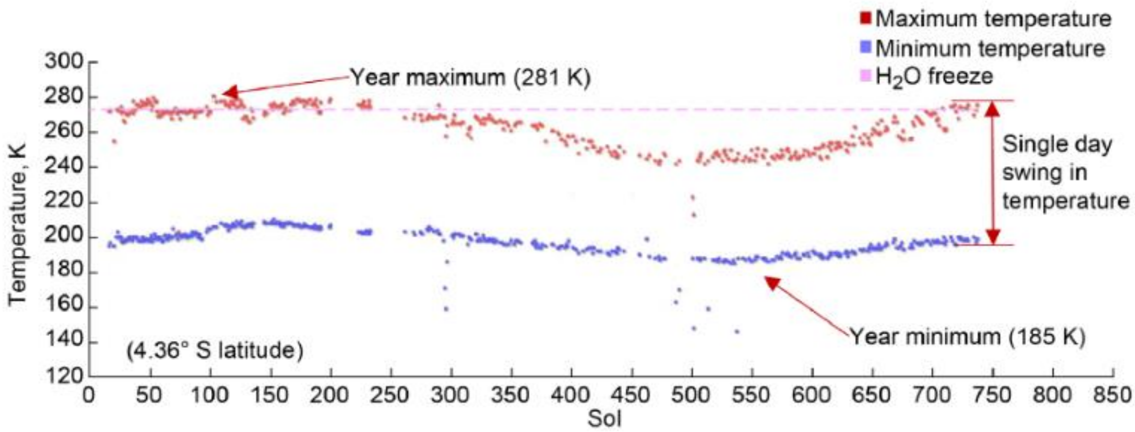


Figure 8.—MSL Curiosity rover surface temperature (Ref. 10).

[Link]

On both Mars and Venus we have the same situation as for Earth, the atmosphere is colder than the surface, no heat flows from a low to a high temperature and that makes a greenhouse effect impossible, even on Venus with its high surface temperature.

Thermodynamic gravity

In all cases where we have a heat flow and a force in the same system, they´re connected and relative to each other. Without knowing the details of how it would work, let´s assume that this relationship is real also for planetary heat flow and gravity. Based only on the fact that it would be true for all other systems, I´ll just assume that the force, in this case gravity, is related to the heat flow in some way.

> *If a body gives off the energy L in the form of radiation, its mass diminishes by* L/c^2. The fact that the energy withdrawn from the body becomes energy of radiation evidently makes no difference, so that we are led to the more general conclusion that
>
> The mass of a body is a measure of its energy-content; if the energy changes by L, the mass changes in the same sense by $L/9 \times 10^{20}$, the energy being measured in ergs, and the mass in grammes.
>
> It is not impossible that with bodies whose energy-content is variable to a high degree (e.g. with radium salts) the theory may be successfully put to the test.
>
> If the theory corresponds to the facts, radiation conveys inertia between the emitting and absorbing bodies.

When Einstein says that a body loses mass proportionally to heat emission it will be as $4\pi r^2\sigma T^4/c^2$=m. On the Earth surface this is $\frac{\sigma 286.6}{c^2} = 4.25 * 10^{-15}kg$ per square meter. $E = mc^2$ can also be written as $\sigma T^4 = mc^2$ because $L = \sigma T^4$, which means that there´s a transfer of mass since mass and heat/energy is equivalent.

$L = mc^2$ says that that heat emission at the surface is equal to accelerating a mass of $4.25 * 10^{-15}kg$ to the speed of light with the total energy equal to a power of $mc^2 = 382.75W/m^2$.

The results below are surprising.

g is surface acceleration according to NASAs earth fact sheet.

$$TSI = 1360.9W/m^2$$

$$\left(\frac{4}{3}\right)^2 16\pi r^2 g^2 = 2\pi r^2 TSI$$

Or as received flux per unit surface area:

$$TSI = \left(\frac{4}{3}\right)^2 8g^2$$

And surface emission is equal to:

$$\sigma 286.6^4 = 4g^2$$

Which means that at the surface we have $mc^2 = 4g^2$.

This makes surface emission on Earth look like the spherical source power of gravity. This may be just a coincidence.

I also found a relationship to σT^4 at the system boundary TOA, the temperature/emissive power at the tropopause, which is the outer boundary of the system. It happens to be equal to $\frac{4}{3}g^2 = \frac{1}{3}\sigma 286.6^4$, a temperature of 218K.

This then connects back to radiation entropy of surface emission in the energy balance in part 3, $\frac{4}{3}\sigma T^3$= $\frac{4}{3}\sigma 286.6^3 = 1.78\, W * m^{-2} * K^{-1}$.

For a surface temperature of 286.6K this means a total entropy flux:

$\frac{4}{3}\sigma 286.6^3 * 286.6 - \sigma 286.6^4 = \frac{4}{3}g^2$.

For Venus the relationship to TSI is $32\pi r^2 g^2 = \pi r^2 TSI$, but not as exactly as on Earth. The error is $\sim g^2$.

On Mars it´s exactly $\frac{4}{3}32\pi r^2 g^2 = \pi r^2 TSI.$ Also, Mars effective emission at 209.8K is equal to $\frac{3}{4}\frac{\pi r^2 TSI}{4\pi r^2} = 8g^2$, and surface emission $\left(\frac{3}{4}\right)^2 \frac{2\pi r^2 TSI}{4\pi r^2} = 12g^2$.

New constant

The relationship between heat and mass is according to Einstein $\sigma T^4 = mc^2$, which means that $\frac{T^4}{m} = \frac{c^2}{\sigma}$, so we have a constant between T^4 and m which is $c^2/\sigma = 1.58510614^{24} K^4 kg^{-1}$. This might explain why there´s a relationship between planetary heat flow and gravity. If there´s a constant relationship between mass and heat flow (T^4), then there must be a constant relationship between gravity and heat flow.

Comments

There seems to be some type of regularity with these relationships between heat flow and gravity, and Earth stands out as a special case where it´s very nicely balanced at the surface. I´m not really satisfied with the result on Venus since the other planets show such a precise relationship.

I don´t make any claims of the mathematical correlations between gravity and heat flow being important or correct, but the fact that there is a constant relationship between temperature and mass supports the idea. The idea that mass accelerated to the speed of light radially outwards is connected to an attractive force in the opposite direction doesn´t seem so far-fetched to me, a reflux of mass proportional to outward acceleration. Also, I like the idea of joining heat and force together on a planet in in line with how thermodynamics always works. What are the consequences of a flow field of mass accelerated to the speed of light with the energy mc^2? Does it curve space? I´m just guessing, I´m at my limits here.

The energy balance model in the will have to speak for itself based on the results.

Of course, this means that there can´t be a greenhouse effect. Planetary temperatures are governed by established thermodynamic principles, which the greenhouse effect isn´t.