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RESEARCH ARTICLE

The Reasons why the Greenhouse Theory is Wrong

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Abstract

This contribution comprises on the one hand a critical review of the CO_2-based greenhouse theory, retracing its origins. On the other hand, it provides arguments, even trivial ones, as to why the Keeling curves cannot be as a proof for the correctness of this theory, and that another cause for climate change has to be considered, namely the darkening of the Earth's surface, particularly in cities. And finally, it refers to a previously published paper of the author where the radiative behaviour of gases is described, applying temperature measurements instead of absorption measurements, but whose quantum mechanical verification could be provided only now.

Keywords: Absorption Measurements for Gases, Keeling Curves, Temperature Measurements at Irradiated Gases, Solar Radiation Reflection, Urban Darkening, Mitigation the Micro-Climate.

1. Introduction

In the climate debate linked to the «energy transition», the greenhouse theory – i.e. the attribution of climate change to the CO_2 content of the air – has been accepted as a fundamental dogma for quite some time already, not least in the wake of the UN-sponsored World Climate Conference in Paris at the end of 2015. Interest in climate change may have waned, but the recent 30th COP conference in Brazil shows that it is still a hot but controversial topic. The primary question here is by when the «climate targets» – i.e. the CO_2 reduction targets – are to be achieved. However, there is no direct, scientifically proven correlation between the CO_2 content of the atmosphere and its temperature. Nevertheless, the whole debate has a scientific veneer, not least because of the numerous publications and media reports, most of which, however, dealt with the fact of climate change rather than its causes. Any objections came mostly from «climate deniers», i.e. those who either completely deny climate change or attribute it solely to natural fluctuations. However, serious concerns raised by individual scientists were consistently ignored.

In addition to the scientifically sophisticated objections to the greenhouse theory related to the complexity of atmospheric physics, there are also trivial objections that are comprehensible to laypersons interested in science. First, however, it is essential to explain how the Earth's atmosphere can be compared to a greenhouse, and how the greenhouse theory came about.

2. To What Extent can the Atmosphere be Compared with a Greenhouse?

Already in 1827, *Fourier* compared Earth's atmosphere with a «hot house», meaning a greenhouse [1]. At that time, radiation physics were in the fledgling stage. Moreover, the comparison fails to hold insofar as in a greenhouse the air is confined, whereas in the atmosphere the air is able to rise upwards and to cool down, in fact – in the stratosphere – to very low temperatures. But in both cases the ground is warmed up by sunlight, passing the heat to the overlaying air, be it by heat conduction, combined with air convection, or by absorbing heat radiation. Not simply evident is a warming up of the air by direct absorption of the sunlight.

Fourier could not know – at least not precisely – that the atmosphere radiates heat towards the Earth's surface, and that the higher its temperature, the more

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heat it radiates. Inversely, the Earth's surface radiates heat, likewise all the more its temperature increases. Its warming-up-rate depends on the intensity of the sun irradiation and on its consistency, in particular on its colouring. Thereby, dark surfaces absorb more completely than bright ones. Both radiations – i.e. the one of the Earth's surface and the one of the atmosphere – increase till they are balanced, having attained a limiting temperature. That depends on the colouring of the ground, thus increasing with its darkness, while it is reduced by air-convection.

As *Stefan* assessed in 1879, based on measurements by *Dulong* and *Petit* already published in 1817, and *Boltzmann* theoretically validated in 1884 [2, 3, 4], the radiation intensity of a Black Body increases proportionally to the fourth power of its absolute temperature. The proportionality factor is named *Stefan-/Boltzmann Constant* and signified by *σ*. A «Black Body» means a body that completely absorbs any light radiation. Thereby, every opaque solid body (thus also a coloured one, even a white one) radiates like a Black Body, whereas its absorption capacity depends on its colouring. Moreover and remarkably, the atmosphere as a whole radiates like a Black Body.

When a defined area of the Earth's surface is irradiated by sunlight, it warms up till the limiting temperature is attained, as already mentioned. (Instead, a solid coloured plate may be considered, serving as a model). Three kinds of radiations are involved: firstly, the radiation of the sunlight, whereby solely a colour-dependent portion is efficient; secondly, the aligned thermal radiation of the atmosphere; and thirdly the counter-acting thermal emission of the Earth's surface (or of the model plate). At the limiting temperature, where all the radiations are in equilibrium, the sum of the first two radiation intensities must be equal to the intensity of the atmospheric counter radiation.

If the intensity of the sun-radiation, the (colour specific) absorption coefficient of the surface, and the temperature of the ambient atmosphere are known, the limiting temperature of the surface can be computed, using the Stefan/Boltzmann relation. When, for example, the following values are known: intensity of the sun-radiation 1000 Wm^{-2}, solar absorption coefficient 0.7 (corresponds to 70%), and air temperature 25° C (= 298 K), the limiting temperature is 377 K = 104 °C. However, that is only the case if the overlaying air is immobilised, preferably by a transparent envelope.

Such conditions most likely exist in solar thermal collectors. The result is plausible, but it depends on the construction of the solar thermal collector. In the case of a greenhouse, the conditions are more complex since there the ground is equipped by plants.

Those facts reveal that the counter-radiation of the atmosphere principally depends on the (absolute) temperature, while trace gases such as CO_2 are irrelevant. Therefore, the assumption that CO_2 is responsible for the temperature rise has already been disproven by empirical evidence. This will additionally be verified in the chapter after next.

An explanation why the atmosphere can absorb and emit heat-radiation is still not available. It was even less available at the end of the 19^{th} century when the primary measurements were made, and when the Stefan/Boltzmann law was established. It solely will be feasible applying quantum-mechanics which provides coherence between matter and radiation. It was founded by *Planck*, whose theory, published in 1900, provided coherence between the temperature of a Black Body and the frequency range of radiation, introducing the constant *h*. Applying the *photoelectric effect*, published by *Einstein* in 1905, *Bohr* presented in 1913 his seminal *atom model of Hydrogen*, which was extended by *Heisenberg*, *Schrödinger* and others to the still valid theory.

However, the explanation of this thermal-radiative behaviour is not possible applying the common theory. Rather, it can be provided by means of the author's own, below shortly described measurements, and the thereon founded theory which has been recently published. In contrast, the absorption measurements in gases, made and interpreted by *Tyndall* in the 1860^s, followed by those of Arrhenius, as well as those of *Plass,* published in the1950st, lead on the wrong track, also because the Stefan-/Boltzmann-Law was misinterpreted. Since they are relevant for the CO_2 doctrine, they are discussed next.

3. The Photometric and Spectroscopic Measurements

Photometric measurements played an important role in the early days of chemistry, as they could be used to determine the concentration of a coloured substance in a solvent. Thereby, the absorption – i.e. the decrease in intensity of a ray of complementarily coloured light is measured by a solution of the relevant substance, filled in a cuvette. Initial problems emerged with respect to the origin of the light source – since at that time no electric light was available, solely candles and oil lamps – as well with respect to the measurement of the light intensity (electric photometers arose even later). The determination of the absorption of thermal radiation, thus of the radiation in the infrared-range, is even more difficult, since interaction with the walls of the container is to be expected, interfering the measurements. Glass is not suited for sealing since it absorbs thermal radiation, thereby warming up.

As reported by *Tyndall*, initial measurements in gases were made by *Melloni* and by *Franz.* He perfected the method and made several publications at the beginning of the 1880s – thus long before the relation of Stefan became known –, in particular [5]. As Figure 1 shows, the instrumental effort was considerable. The basic measuring tube consisted of a metal (mostly of tin or of brass). It was sealed on both sides by compact plates from Rock-salt (sodium chloride), so that it could be evacuated by a pump and subsequently filled with the relevant gas. So-called *Leslie-cubes* (i.e. metallic hollow cubes which were filled with water and heated-up by a Bunsen-burner to the boiling point of water). One of these Leslie-cubes (C) served as a radiation source, while the other one (C'), being equipped with a double-screen, served as a compensator. The intensity difference of both radiations at the apex P was determined by a thermopile and a galvanometer.

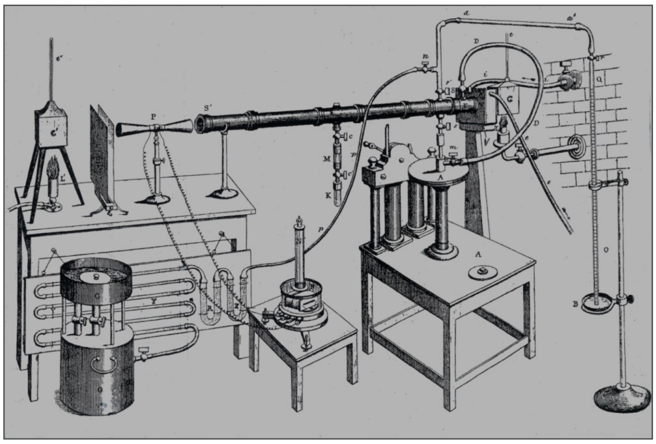

Figure 1. *The measurement device of Tyndall according to [5]*

The measurements yielded that nitrogen, oxygen and hydrogen, in contrast to water vapour, carbon-dioxide (there called carbonic acid) and so-called «olefiant» gases (e.g. ethyl ether) did not absorb. Thereby, the respective absorption values were not given absolutely but solely relatively since the radiation intensity was not known.

Further measurements yielded that dried, through potash (potassium carbonate) led air only poorly absorbed, whereas the absorption by untreated, moisty laboratory air which presumably contained some sulphur-oxide (due to the use of a lamp) absorbed approx. to the same degree as pure carbon-dioxide. Since the concentration of carbon-dioxide in air is quite small (in an occupied room it might be approx. 600 ppm = 0.06 %, but it had not been measured then), Tyndall concluded that water vapour must deliver the cause for climate change, which had already been realized at that time. Obviously, that assessment was subsequently neglected by the subsequent experts while CO_2 was hold responsible for climate change.

However, the assumption of Tyndall that water vapour would be responsible for climate change appears to be not plausible since its concentration in the atmosphere is subjected to considerable fluctuations, solely explaining weather fluctuations. But in particular, it was not realized that this method solely provides absorption values for the thermal radiation, and **not** temperature value**s**, i.e. the warming-up of the gases was not measured, solely their absorption behaviour. Indeed, there exists no theoretically deducible relation between those parameters. Rather it is conceivable that the absorbed radiation is re-emitted – in fact in all directions –, without having led to warming-up the gas.

At the end of the 19th century, *Arrhenius* tried to apply the meanwhile well-known Stefan-/Boltzmann formula onto the whole atmosphere by relating the Space to the Earth's surface – instead of considering the contact zone between the atmosphere and the Earth's surface [6]. But this is not permissible as there is the atmosphere between the two in which complex physical processes take place. Moreover, he tried to portray the CO_2 as the origin of climate change, in spite of the fact that it is irrelevant, due to its low concentration. Nevertheless, this concept was later adopted even though it is fundamentally wrong.

In the 1950s, *Plass* re-established it, applying the meanwhile commonly adopted infrared-spectroscopy

[7]. Its principle is the same as the one which is applied for photometry, except that the radiographed IR-light is scattered by a prism, engendering a wave-dependent spectrum. This method is of considerable significance in organic chemistry since it provides important indications for molecular structures. However, it is not suited for exact concentration measurements.

The arguments, why the application on atmospheric and thus on climatic conditions is not feasible, are identical for Plass's theory and for the theory of Tyndall and of Arrhenius. Nevertheless, a considerable publication activity about the CO_2-doctrine evolved, in principle maintaining the view of Arrhenius. Based on the difference between the theoretically computed average Earth's surface temperature of 250 K (= -23 °C) and the effective surface temperature of 290 K (= +17 °C), it was concluded that the CO_2 in the atmosphere was responsible for this gap and that an additional factor in the form of the so-called *radiative transfer* must be relevant ([8] [9]). Hereto, different theories exist, but which are not able to deliver direct theoretical coherence between the CO_2-content of the air and its temperature (see also [10]). Instead, the *Keeling-curves* should furnish evidence for coherence between the CO_2-concentration and the temperature of the atmosphere.

4. A Misleading Analogical Conclusion

The empirical evidence for the correctness of the CO_2-greenhouse-theory propagated by *Plass* seemed to be furnished by the measured values by *Charles David Keeling* compiled over a period of twenty years, namely from 1958 till 1978. He measured the CO_2-concentrations in air at the two different locations Mouna Loa volcano in Hawai'i (Pacific Ocean, near the northern Tropic) and a location near the South Pole. Thereby he got strikingly consistent values (see Figures 2a and 2b) which found wide echo not only in professional circles but also in popular scientific books about climate change. After Keeling's decease (2005), the measurements at Mona Loa have continued until today. Thereby, most people were probably not aware that the used concentration unit «ppm» (parts per million) is extremely small since 100 ppm merely correspond to 0.01 %.

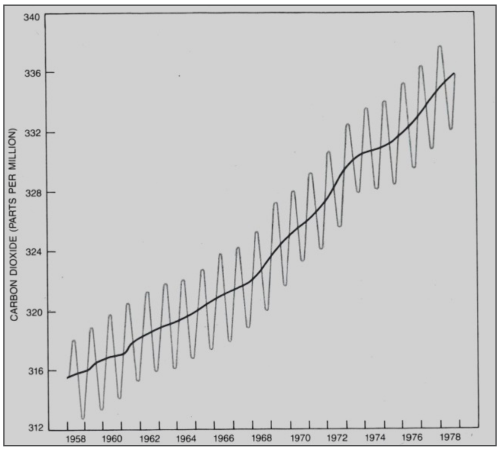

Figure 2a. *measured on the Mauna Loa*

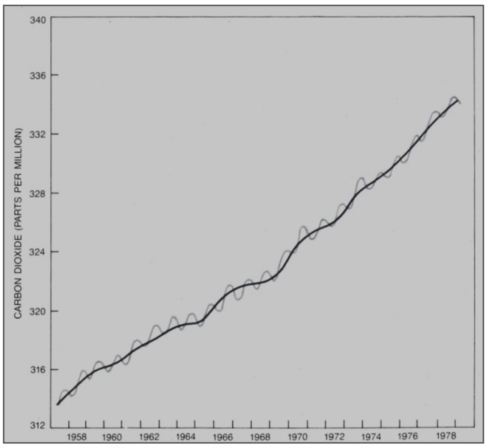

Figure 2b. *measured at the South Pole*

Figure 2. *Keeling curves for the period 1958 – 1978, according to [11]*

At both locations the concentration increase was similar, namely from approx. 314 ppm to approx. 334 ppm. Thus the increase within 20 years was 20 ppm, which corresponds to 6.4 % of the initial value. The differences of the seasonal variations (brighter at the different locations curves) may be explained by the fact that the vegetation activity, which influences the CO_2-content of the air, is smaller at the South Pole than at the position near the equator.

Respective data for temperature measurements are not provided by Keeling. Hereto, other results must be used, for example those of the NASA which trace back to the year 1880 (Figure 3). There, solely the values relative to an average reference temperature are given. Thus, in order to know the effective temperatures, additional data are required.

But apart from the question of how it could be possible to determine the average global temperature in 1880 while many less temperature values were available at that time than nowadays, the following circumstance must be taken into account:

According to thermodynamics, the heat content of a gas – and thus of the atmosphere – is proportional to its absolute temperature, expressed in Kelvin, and not to its relative temperature, expressed in Celsius. Regarding the period of the Keeling curves, the relative temperature rise over twenty years amounts to 0.7 °C. If we assume an average temperature of 14.9

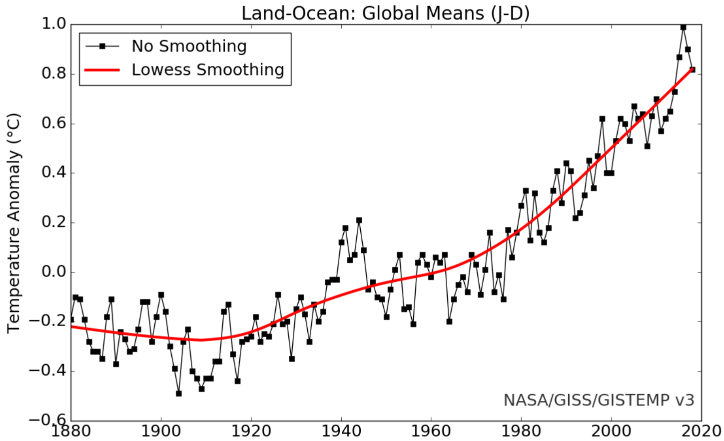

Figure 3. *Annual fluctuations of the global temperature between 1880 and 2020, referenced to the average value https://science.nasa.gov/earth/explore/earth-indicators/global-temperature/*

°C = 288 K according to *Copernicus* data in 2020, the absolute temperature increase is 0.24 %. This value is more than 25 times lower than the one for the CO_2-increase!

As the following comparison reveals, there is not even a direct correlation between the emission of artificially generated CO_2 and the CO_2-concentration in the air: During the Keeling-period between 1958 and 1978 the CO_2-emissions rose from 10 billion t to 19 billion t [1], i.e. by 90 % and thus fourteen times more than the CO_2-content of the air.

The CO_2-budget of the Earth's atmosphere is very complex, and cannot be reduced to the fossil fuels such as pit-coal, charcoal, crude oil, petroleum products, cracked gas, and natural gas. Moreover, wood and biomass are decomposed or burned, not least by forest fires. An additional part is generated by the breathing of animals and humans. On the other hand, CO_2 is assimilated by plants and algae, while a considerable part is absorbed by rain and neutralized by lime, according to the chemical equation

$$H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$$

Deforestation of rainforests has no doubt reduced the global assimilation capacity, leading to a higher CO_2-concentration in the air.

But this is not the cause of climate change. Obviously, the warming-up of the Earth's surface has occurred simultaneously with other factors of civilisation, namely with changes of the Earth's surface, in particular due to the increase of urbanisation which goes hand in hand with the rise of the global population. Thereby, the most relevant factor is here the darkening of surfaces, in particular of roofs, since dark surfaces absorb sunlight more strongly than bright surfaces, and convert it into heat. The so-called surface roughness, i.e. the presence of tall buildings, plays an additional role since they induce up-winds, due to temperature gradients. Altogether, climate change cannot be reduced to a rise in temperature but it also leads to an increase in winds and storms.

One obvious argument for this this is the fact that large cities become exceptionally warm which led to the term «Urban Heat Islands». On the other hand, the increase in surface temperature does not only depend on the latitude and on the altitude of a location but also on the nature of the landscape. Thus rural landscapes behave differently from urban ones. Such a difference would not occur if climate change depended on the uniform distribution of CO_2 or on other trace gases. In particular, the enhanced climatic temperature decrease at the poles is mainly ascribable to the reduced reflection of sunlight as a feedback of the melted glaciers and reduced ice surfaces.

5. The Radiative Behaviour of the Atmosphere

As initially mentioned, the Earth's atmosphere is able to emit and to absorb heat radiation. If we exclude influence of CO_2 or of other trace gases, owing to their poor concentrations, hereto no scientific explanation exists so far. Thus, the author's respective results are breaking new ground. They were published already in 2016 [12], but it was ignored in professional circles as well as in the public view, so they are briefly describe below.

In contrast to the hitherto applied methods where always the IR-absorption by gases was measured, in this case the temperature elevation of gases, due to thermal irradiation, was detected. Thereto, 1 m long and 25 cm wide quadratic tubes from Styrofoam were

[1] https://de.statista.com/statistik/daten/studie/37187/umfrage/der-weltweite-co2-ausstoss-seit-1751/

used in which the relevant gas was enclosed through thin plastic foils. The irradiation was engendered either by sunlight (Figure 4) or by an IR-spot mounted at top (Figure 5). Three thermometers were attached in a constant distance, one ahead, one in the middle, and one beneath.

Figure 4. *Solarrohr, according to [12]*

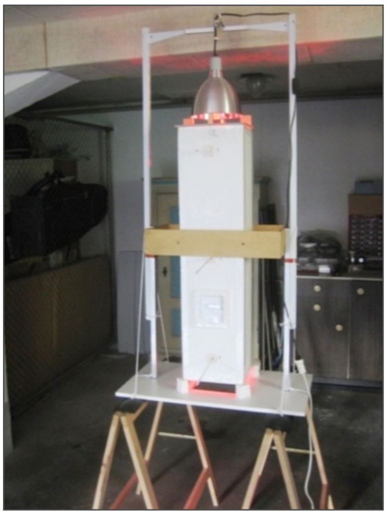

Figure 5. *Heat radiation tube with IR-spot, according to [12]*

The use of sunlight had the advantage that the intensity of the irradiation was constant along the tube, since the distance between the sun and the Earth is very large. Its disadvantage consisted in the relatively low portion of thermal radiation. Moreover, the intensity of sunlight is subject to considerable fluctuations. As a consequence, the measurements could only be carried out in summer at noon within a short time (30 minutes) whereby the solar tube permanently was brought into the line with the sun position (Figure 6).

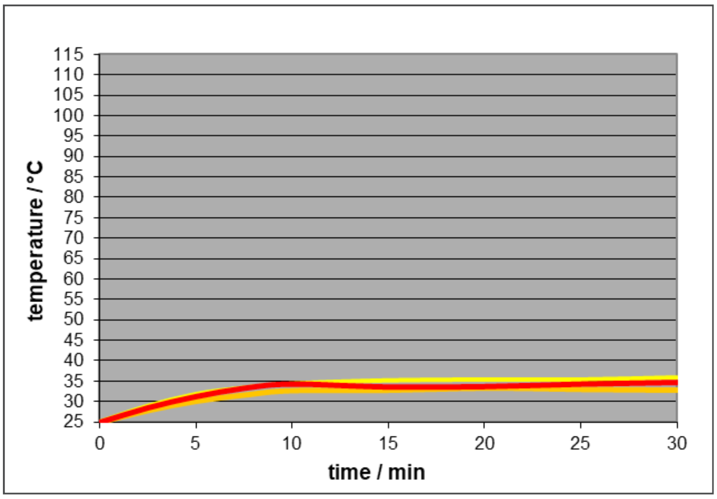

Figure 6. *Outdoor solar-tube, filled with air, irradiation wattage 1000 Wm^{-2} (measured by an electronic pyranometer): Temporal courses at the three thermometer positions (Figure 20 in [12]).*

The use of artificial light had the advantage that high intensities were attainable (150 W spot ≡ 4167 Wm^{-2}), and that the working conditions were constant. The disadvantage consisted therein that the intensity decreased with increasing distance, independent of the nature of the enclosed gas. Such a decrease proceeds also in the vacuum, but it depends on the construction of the tube (Figure 7). In order to minimize this effect, the components of the measuring were mirrored by thin aluminium-foils. The details of the optimizations are described in [12].

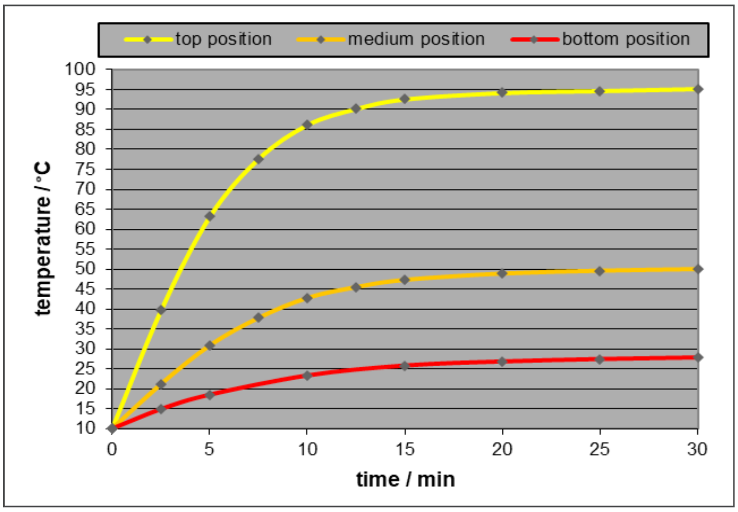

Figure 7. *Heat radiation tube (not optimized), filled with air, 150 W IR-spot: Temporal courses at the three thermometer positions (Figure 9 in [12])*

The first experiments were carried out with natural air and with CO_2. Surprisingly, both gases behaved nearly equally, whereby the temperatures increased immediately at all positions after plugging the light source till a limiting temperature was attained where the emission and the absorption intensities were equal. The fact that the temperature increase started simultaneously at all positions delivered the proof that thermal radiation and not thermal conduction was responsible for the warming-up.

Afterwards, artificial air (i.e. a 4:1 nitrogen-/oxygen-mixture) as well as the noble gases Argon, Neon and Helium were tested. The results by artificial (dry) air did not significantly differ from the results by natural (moist) air, whereas the results by the noble gases differed considerable (see Figure 8).

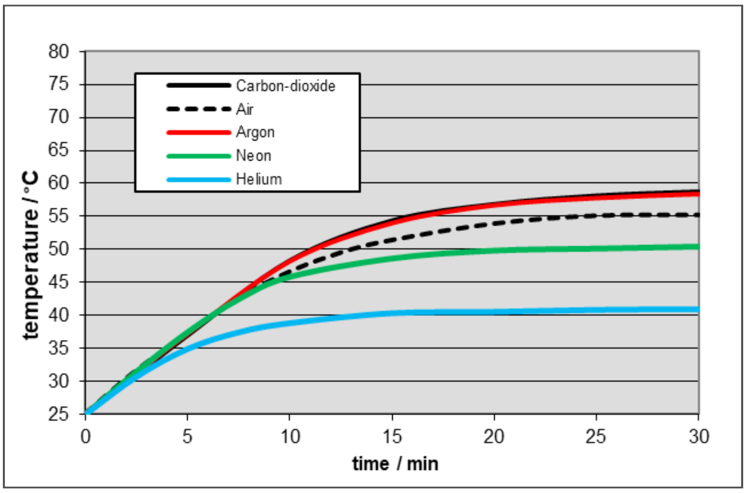

Figure 8. *Time-/temperature courses of different gases (150 W-spot, middle thermometer position), according to [12]*

Similar results comparing air, carbon-dioxide and Argon were independently obtained by *Seim* and *Olsen* [13]. They contradict the results of the photometric and the spectroscopic absorption measurements since those observe a significant difference between the efficient carbon-dioxide and the inefficient air. This means that the heat-inducing thermal absorption is so weak that it cannot be detected spectroscopically, whereas the spectroscopically detectable absorption does not lead to a temperature rise since it occurs over a different mechanism.

The differences at the noble gases could be explained by applying the kinetic gas theory. Thereby the collision wattage of the atoms turned out to be relevant. In that regard, coherence between the emission intensity and the gas pressure together with the root of the absolute temperature was found. This theoretical finding could be verified by comparative measurements at the Furka-summit (on a mountain in Switzerland; low atmospheric pressure) and in Glattbrugg (near Zurich; high atmospheric pressure) [14]. The hereof defined *atmospheric emission constant A* yielded a value of approx. 22 $Wm^{-2}bar^{-1}K^{-0.5}$. This means that the atmosphere radiates back versus the ground and thus elevates the temperature. Since the atmospheric pressure in the mountains is lower than in the lowlands it is colder there although the solar irradiation is more intense there.

In meteorology the temperature lowering in high levels is ascribed to the air expansion due to the pressure lowering. Hereto, an approximate formula exists. But that does not explain the circumstances in extensive highlands.

Indeed, the atmosphere engenders the like of a greenhouse effect. However, trace gases such as CO_2 do not have any respective influence. Instead, the atmospheric pressure is relevant, above all depending on the sea level.

This finding contradicts the supposition that the atmosphere behaves like a Black Body, where the radiation intensity is proportional to the fourth power of the absolute temperature, thus where the pressure does not occur. Since in exact natural science it is not permissible to apply two different formulas in order to explain the same phenomenon, the Black Body hypothesis is probably only approximatively and not exactly valid.

A theoretical verification of the here assumed approach is feasible by means of quantum mechanics, assuming coherence between the thermal radiation and the oscillation of the atomic electron shell. However, the orthodox quantum mechanics must be modified, assuming well-defined electron trajectories instead of blurred fuzzy orbitals, see Figure 9 [15, 16].

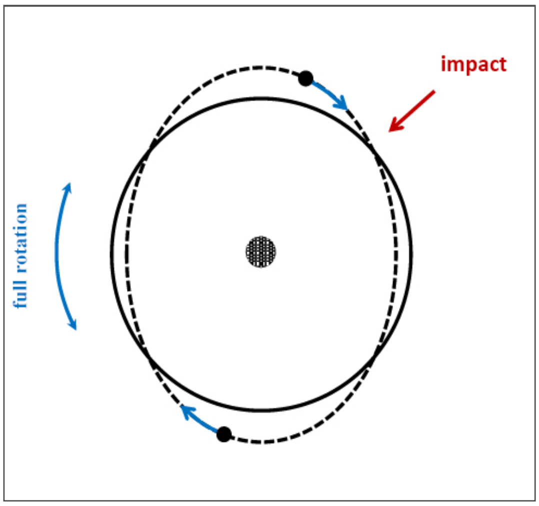

Figure 9. *Orbit of the electrons in a Helium atom as a result of a collision or a thermal-radiative excitation (= dotted curve)*

6. Conclusions

The existence of a radiation equilibrium at the boundary between the Earth's atmosphere and the ground reveals that the atmosphere is able to emit thermal radiation in such a way that the atmosphere engenders the like of a greenhouse effect. Thereby, the atmosphere seems to emit thermal radiation like a Black Body, according to the Stefan-/Boltzmann-Law. But this fact appeared not to be comprehensible, at least when the original photometric results of Tyndall were considered. They yielded that the gases which are predominant in the atmosphere, namely nitrogen and oxygen, do not absorb thermal radiation, in contrast to «olefiant» gases such as carbon-dioxide and water vapour. Although its concentration is extremely low, the doctrine became generally accepted that CO_2 was the cause for climate change. As empirical evidence, the Keeling-curves were alleged. However, as herewith outlined, no direct quantitative correlation exists between the warming-up of the Earth's surface and the behaviour of the Keeling-curves. Rather, the darkening of the Earth's surface, in particular in cities, has to be assumed as the real cause of climate change. Moreover, the explanation of the radiative behaviour of gases – even of noble gases – is feasible by the author's contribution which was published already in 2016, applying temperature measurements instead of absorption measurements, but whose quantum mechanical explanation could be provided only now.

As a consequence, the only possibility of mitigating the climate consists in the brightening-up of the Earth's surface, particularly in cities, and preferably at roofs. And a practical method of determining the solar absorption coefficient of coloured plates is given in [17], while suggestions for mitigating the micro-climate are made in [18].

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