Global Warming Gas Balance in Response to Increasing Concentrations: Discovery of an Unknown Independent Emission Saturation Mechanism for Infrared Radiation

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Abstract

Tremendous work and results of prognostic models were yielded in the field of global warming in the past three decades. In laser experiments with a XeCl-excimer laser, we photographed the ablation process and gas evaporation in form of a gas-bubble using ultrafast imaging. Analysing the results, we were able to detect an intrinsic independent emission saturation mechanism of global warming gases, which is most probably relevant for the stagnation of mean temperature in the atmosphere observed nowadays \( r = 0.99 \). While the saturation of global warming gases depends on the revealed special relation between the logarithm of the total charge of the nucleus-electron system and the logarithm of the wavelength of absorbed rays, which is an important new finding, an increase in concentration of global warming gases upon a specific emission saturation level can create an imbalance leading to a stagnation of atmospheric temperature increase (emission saturation concentration of \( \text{CO}_2 = 364.203119986 \) ppm). The formula which we calculated is able to accurately predict atmospheric warming and global climate changes.

Keywords

Global Warming, Laser Ablation, \( \text{CO}_2 \) Gas Dynamics

1. Introduction

Using the technique of ultra-fast imaging, the temporal development and spatial distribution of the laser ablation have been visualized by several groups [1]. Several studies [2] [3] have reported on the results of non-contact
tissue ablation by a mid-infra-red holmium laser ablation under atmospheric conditions using a fiber delivery system [4] [5]. The current investigation was performed irradiating tissue samples in a 0.9% saline solution in order to simulate comparable conditions of laser irradiation as in the clinical setting as well as to analyze the underlying mechanism associated with laser ablation.

The results of this study offer width and new understanding of the mechanism of the absorption/emission process in a global warming gas and explain how energy is emitted under irradiation or other general electromagnetic conditions.

2. Methods

2.1 Tissue Specimens

Thirty samples of tissue specimens were investigated using ultrafast imaging. Beside healthy tissue the arterial segments showed different types of atherosclerotic plaques, from lipid rich to hard calcified plaques. The fresh vessels were cut into a size of at least 2 cm × 2 cm and placed in a quartz cuvette containing a 0.9% saline solution.

2.2. Experimental Set-Up

A XeCl excimer laser (Lambda-Physik LPX 210ICC) with a wavelength of a 308 nm and a pulsed width of 30 ns (full width at half-maximum [FWHM]) was used for tissue ablation. The pulses were transmitted through a fixed 600 μm fused silica fiber with the fiber tip pointing perpendicular to the vascular surface. The energy at the distal end of the fiber was adjusted with a variable attenuator. The pulse energy was set to 20 mJ, which corresponds to fluences of about 7 J/cm² at the distal end of the fiber. The ablation threshold is about 1 - 4 J/cm² [6]. Visible radiation of a pulsed dye laser operated at a wavelength of 580 nm with a pulse width of about 10 ns FWHM was used to illuminate the tissue surface for visualization of the ablation process. This system served as a flash light source for the imaging process. A fast photo-diode in combination with a digital storing oscilloscope was used to monitor the delay time between the ablation and the dye laser pulse. The ablation process was recorded by a CCD camera for each excimer laser pulse. Trafferring and delaying of both laser systems were controlled by a PC via an electronic pulse generator (Hewlett Packard) which allowed reproducible adjustment of delay times in the range of nanoseconds up to hundreds of microseconds. The CCD camera was attached to a PC-based image-processing system to record the photographed ablation process. The magnification factor of the microscope imaging system was 16.

2.3. Study Design

Care was taken to photograph the ablation side without shadowing of adjacent segments. At increasing delay times with a step of 5 μs series of pictures were recorded from calcified and fatty plaques as well as from normal arteries. Since the repetition rate of the excimer laser pumped dye laser is much too low for high speed cinematography, only single pictures at certain delay times have been recorded for each ablating pulse. By means of a micro-manipulator, the fiber tip was fixed at a 0.5 mm distance to the sample. In direct contact to the tissue, a second fiber was adjusted. Each laser pulse was applied to different positions of the same plaque specimen. This was achieved by moving the samples via the micro-manipulator in steps of 800 μm.

2.4. Statistical Analysis

We calculated the volume of the observed bubble assuming rotational symmetry based on the model of a sphere segment. All values are expressed as mean ± SD, if not otherwise indicated. The deviation from a sphere was estimated by averaging the difference between the volume of a spherical segment completely enclosing a bubble and the volume of a spherical segment completely included in the same bubble. Bubbles with an estimated error > 10% of the calculated volume were excluded from this analysis. The maximal bubble volume from atherosclerotic plaques, fatty and normal vessels was compared by using an unpaired t-test. p values < 0.05 were regarded as significant.

3. Results

Thirty aortic specimens were irradiated using an excimer laser [7]. Each photograph was recorded at different
delay time. The photographs were taken at a delay time ranging up to several hundreds of microseconds after the ablation laser pulse. At two microseconds after ablation is initiated a spherical bubble starts developing from the tissue surface. A maximal extension is reached after 50 to 70 µs after growing steadily, and then it begins to collapse (Figure 1).

Assuming rotational symmetry and using the simple model of a spherical segment, the volume $V$ of the observed bubble can be described according to:

$$V = \frac{\pi h}{6} \left( 3r^2 + h^2 \right)$$

where $r$ is the radius and $h$ the height of the spherical segment. The expansion of the calculated volume was different for normal tissue and calcified plaques resulting in different slopes of the figured curves. For the later type of tissue a considerably steeper increase of the bubble volume was noted ($p = 0.0001$). The bubbles revealed a maximum after 40 - 50 µs in case of calcified plaques and after 50 - 70 µs after irradiation of normal arterial wall (Table 1). The maximal extension of the bubble was considerably higher for calcified than for normal tissue. The evaluated data for irradiation of fatty plaques was quite similar to that of normal specimens.

In direct contact of the laser tip to the tissue surface a bubble rises from the tissue after about 10 µs. This bubble has an irregular shape and, in comparison to non-contact tissue ablation, appears somewhat suppressed. A maximum is already reached at a delay time of 40 to 45 µs, the collapse is followed by an ejection of small particles emerging from the irradiated area.

The revealed volume velocities in the increasing phase were related to those of the decreasing phase in 720 photographs according the calculated relation [4]. The overall mean difference was 0.004, the correlation coefficient was assessed as 0.99.

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**Figure 1.** Series of photographs taken from normal tissue at different delay times with the experimental setup shown above (distance between fiber tip and the tissue surface: 0.5 mm). The distal end of the fiber appears as a transparent bar pointing from the top in each photograph. The irregular horizontal contour in front of the illuminated background is the lateral view of the tissue surface. The ablation process is figured as an increasing bubble appearing as a shadow. Delay times a) 0 µs; b) 2 µs; c) 20 µs; d) 40 µs; e) 60 µs; f) 100 µs.
Table 1. Time course of the calculated bubble volume for thirty samples with calcified and fatty plaques and for normal aortic wall.

| Tissue samples | Calcified | Fatty | Normal |
|----------------|-----------|-------|--------|
| Accuracy (mm³) | 0.004 ± 0.07 | 0.06 ± 0.08 | 0.04 ± 0.05 |
| Delay time at the maximal volume (μs) | 40 - 50 | 30 - 55 | 50 - 70 |
| Maximal volume (mm³) | 1.31 ± 0.43 | 0.34 ± 0.11 | 0.32 ± 0.25 |
| Lifetime (μs) | 130 - 160 | 100 - 120 | 100 - 140 |
| Volume increase after rise (cm³/s) | 30.2 ± 9.2 | 11.4 ± 4.9 | 5.4 ± 1.9 |

4. Discussion

Using ultra-fast imaging a cavitation bubble, which increased upon the tissue surface under saline solution, could be photographed, which collapsed after an increase of approximately 153 microseconds. In these bubbles certainly a great amount of carbon dioxide can be found. But what happens during the bubble expands and when does the absorption/emission process takes place? Beside medical aspects of laser irradiation on the radiated tissue, which were reported in the journal Lasers in Surgery and Medicine [7], the changes of the observed bubble volumes in time (and the underlying electromagnetic aspects) were subject of several calculations and sub-analysis in order to analyze possible correlations of these volumes with ray-specific parameters. Since the volume change of the bubble correlates to energy changes occurring within the bubble, direct conclusions for the electromagnetic process of ablation and emission in the CO₂-gas (contained in the bubble) could be drawn using ultrafast imaging. Increasing global warming gas concentrations can lead to an increased absorption of infrared rays and to an increase of mean temperature [6]. But how does the emission process behave in this scenario? Due to the current opinion a simultaneous elevation of the emission process subsequently takes place [6]. In order to determine the emission behavior we first had to point out, which atomic or molecular processes play a role in this emission mechanism. While infra-red rays are absorbed by atoms of global warming gases, they lose their energy, which is used to activate an electron. This electron can than escape from its orbital, while it moves to the next higher orbital. By capturing the Coulomb-binding energy a photon is emitted [8]. To calculated energy changes within the bubble during its expansion and collapse, we had to take into account that energy transmission correlates to the Coulomb force between a nucleus and an electron (q²/4πε₀r). The process of emission is governed by the lost binding energy of the electron to its nucleus, allowing it when the hereby needed energy can be gathered by the molecule. Therefore, we first calculated energy changes of the lost binding energy (of the electron to its nucleus) in order to allow emission of a photon as:

\[
P(t) = a_1 \log \frac{\lambda^2 \log q^2}{\log \left(\log q^2 - \log \lambda^2\right)} \cdot nk_\beta T
\]

whereas the for emission “needed” energy of a photon was calculated as:

\[
P(t) = a_2 \frac{\log \lambda^2 \log q^2}{\log \left(\log q^2 - \log \lambda^2\right)} \cdot \left(\frac{\sigma^*}{\sigma}\right) nk_\beta T
\]

σ = 1/tₐ, σ’ = fₐ(λ)/fₐ = fₐ(q)/fₐ = constant (tₐ and tₑ is the total absorption respectively emission time), σ* = f(λ,q) \left(1/\log ^2 - 1/\log ^2\right)/fₐ, f are factors, which result from transformation of \log q^2/4πε₀r into \log q^2/λ₂ or \log q^2 and \log q^2, n is the number of molecules contained in the reference volume and π is the number of the orbital of the electron. There is a fixed relation between the absorption energy and the activation of the electron on the one hand and the for emission needed energy and the emission of a photon on the other hand, since the relative energy changes of the emission of a photon are equal to that of the activation of an electron (in order to maintain the energy equality in a system). Equating the two Formulas (1) and (2), we revealed a special relation that implies that the product of the logarithm of the square wavelength and the logarithm of the square
electric charge are equal to their sum:

$$\log \lambda^2 = \log q^2 = \log \lambda^2 + \log q^2$$

(4)

since \(a_1\) is equal to \(a_2\). Hence, when the energy changes of the “needed” energy is below the power of the lost binding energy of the nucleus, a photon can be easily generated. However, additional emission cannot occur any more, when the power of the (for emission) needed energy is greater than this binding energy, in order to allow energy maintenance. Therefore, the temperature of the gas does not increase any more, even if the gas will be further warmed (missing thermalisation due to the emission saturation).

Whereas in the increasing phase parts of the absorption process for infra-red rays take place, in the collapsing phase emission of generated infra-red rays predominates. Analyzing the bubble volumes (30 series of photographs) we could reveal, that the increasing phase of the bubble extension and the collapsing phase were accordingly related to each other in regard of their logarithmic part of the volume change in time, their product being equal (mean difference 0.004; \(r = 0.99\)) to the sum of the two positive values, a fact, which significantly confirms the relation calculated in Formula (4) and the hypothesis of emission saturation upon a saturation point. Therefore, the results show that the saturation of the CO\(_2\)-gas in these experiments depends on the calculated relation (4), whereas the amount of emission is guarded and limited by this energy management way, which is an important new finding.

4.1. Impact on Global Warming

In the atmosphere, the same process of balancing, which happens in microseconds after laser irradiation seems to lead under certain circumstances to a stagnation of mean temperature. But how can than the temperature increase furthermore, like it is known for the actual climate changes? The emission out of spectral areas, which emits only slightly or does not emit at all, or which emits from the side corner of the absorption for infrared radiation, is well known [8]. The atoms included in the global warming gases together with their isotopes (C\(^{13}\), C\(^{14}\), N\(^{16}\), F\(^{19}\), O\(^{17}\), O\(^{18}\)), are able to emit photons after absorption of infrared rays. However, with increasing concentrations of CO\(_2\) emission of infrared rays is limited by the revealed relation (4). That means for instance that at lower concentrations all CO\(_2\) molecules (and the molecules of other global warming gases) are able to emit infrared rays, whereas at higher concentrations only a limited amount of CO\(_2\) molecules, which is related to the CO\(_2\) saturation concentration, is further involved in the emission mechanism. Therefore, the emission process is only a limited (saturated) process. If the concentration of CO\(_2\) reaches a certain value (\(c = 364.203119986\) ppm), CO\(_2\) molecules will partly lose their emission capability, which is independent from its ability to absorb infrared rays.

The anthropogenic emission of CO\(_2\) could lead to an increase of the temperature of 1.5°C to 2.0°C till the end of the 21 century [9], if the above described process wouldn’t take place, which may stop the progress of global warming. Due to the accumulation of anthropogenic emission in the atmosphere the part of isotopes C\(^{14}\) and C\(^{13}\) will shift to C\(^{12}\), which leads by combustion of fossil fuels to an increased C\(^{12}\) concentration (and in a low amount of C\(^{15}\)) in the atmosphere, which will have as a result, that the temperature upon a specific value will not increase any more, since the isotopes C\(^{13}\) and C\(^{14}\), which are responsible for the increase of temperature at low charges, are not available any more. This stagnation effect takes already place (at CO\(_2\)-concentration of 364.203 ppm). In the atmosphere, there can be found already nowadays a great amount of anthropogenic CO\(_2\) (40%).

Caused by the revealed emission saturation mechanism the CO\(_2\) molecules—and this is the good news—have lost their explosive stuff 1998 and the temperature is not increasing furthermore. The stagnating global temperatures from the past 16 years are an indication of the accuracy of these calculations. This stagnation is thus most likely a result of emission saturation of global warming gases such as CO\(_2\), rather than by cool ocean currents in the Pacific related cooling, as reported by scientists from the United States in the journal Science. Thus, due to this effect the global mean temperature on earth will not rise any more, provided that the methane and nitrous oxide levels are not increasing significantly (these gases are not saturated in the atmosphere and can thus additionally heat the atmosphere).

4.2. Solar Activity

The sun activity (De-Vries cycles) with a consecutive decrease of the cloud density, may play a significant role
for global warming. This is in our opinion only relevant for unsaturated atmospheric gases like methane, NO₂ and FCKW, since a more of warming radiation upon the saturation point cannot warm the atmosphere any further. The effect of the solar activity on global warming is subject of many controversial debates. Whereas some climate researchers (H. Svensmarc, H. Malberg) consider this effect (over the past 200 years) as statistically significant [9], other scientists have come to another conclusion: the integral solar effect is low rather than being relevant [10] [11]. We estimate the direct influence of an increased solar activity as being low, since the concentration of global warming gases like methane and laughing gas is only low compared to the CO₂ concentration (but owning a higher warming potential), when assuming that the cloud density has really decreased in the past 150 years.

4.3. Absorption and Emission Energy in the Atmosphere

The global warming gases absorb the infrared radiation up to 98.5%, which is radiated by the earth surface in the specific wavelengths. This shows that CO₂ can absorb a great amount of infrared radiation. The process, which does not warm the global warming gases further after reaching a certain temperature, occurs under laboratory conditions abrupt and not gradually, like one would expect in case of absorption saturation. The missing thermalisation is in our opinion caused by emission saturation and only in the second line by an absorption saturation, which relies on a totally different principle. The absorption of CO₂ can be described as

\[
P = 4.606 \cdot f(t) \cdot \sigma'(\log \lambda^2) \frac{q^2 k}{ecr} \left[ \text{J/s} \right]
\]

\[
\sigma' = 7.832 \times 10^{14} \cdot c^3 \left( 1 - \frac{\log q^2}{\log \lambda^2} \right)
\]

whereas \(q\) is the charge coefficient, \(c\) the extinction coefficient and \(c\) is the gas concentration in parts per million (emission saturation concentration). The \(V(t)\)-curve is almost linear (Figure 2) for the absorption—as well as for the emission process and given absorption and emission wavelengths and charges. The saturation concentration of CO₂ at defined absorption wavelength (lowest 4 µm) can be calculated as:

![Figure 2. Diagram of the volume changes of the photographed bubble in time, with a) laser ablation of normal specimen; b) ablation of fatty and c) ablation of calcified specimen. The increasing phase of the laser ablation in c) reveals a constant 30.2 cm³/s velocity of increase, whereas the collapsing phase owns an also constant 13.0 cm³/s velocity.](image)
\[ c = \frac{1.27687 \times 10^{-15} q}{Q \cdot N} \left(1 - \sqrt[3]{\frac{\log q^2}{\log \lambda^2}}\right) \]

\[ c = 364.203119986 \text{ ppm} \]

\((N_0)\) is the number of molecules in 1 l air, \(Q\) is the charge of the nucleus-electron-system in the CO\(_2\) gas, \(q\) is the total electric charge. This is, however, the measured concentration of CO\(_2\) in the year 1998, since the year 1998 the mean temperature did, however, not show any further increase. Some scientists claimed that the mean earth temperature is not constant but has slowly increased in the last 16 years, but this perception has not been validated. The majority of climate experts assume that no further increase in mean temperature took place in the last 15 - 16 years. The accuracy of this value and the other calculations are therefore extremely high. This high accuracy is also due to the high correlation coefficient of 0.99 calculated for the 720 assessed and photographed bubble volumes, which significantly fit with the theoretically calculated Formula (4), confirming the described hypothesis of the emission saturation process of CO\(_2\) molecules.

4.4. Limitations of the Study

These described experiments performed to establish the underlying process associated with laser ablation on human tissue could result in a totally different field unexpected important findings concerning the saturation mechanism of global warming gases. While these results could be very important for climate changes, detailed evaluation for their impact on global warming would also require (i) calculation of the impact on spectral emissivity of the supposed mechanism, (ii) radiative transfer calculations to determine the impact of (i) on time-varying radiative forcing and (iii) simulation of the impact of (ii) on transient climatic change, which have not been assessed in the present study. Moreover, whether the assessed saturation mechanism can be extrapolated from a laser-induced gas vaporization with the formation of a gas bubble to atmospheric conditions remains unclear. Further studies are therefore needed to determine the impact of these results on atmospheric warming. The future and the further course of the mean temperature on earth will show, whether our measurements and calculations are accurate and whether they might be the underlying cause for the actual stagnation of mean temperature at constant levels.

References

[1] Haase, K.K., Wehrmann, M., Duda, S. and Karsch, K.R. (1990) Experimental Intracoronary Excimer Laser Angioplasty. Z Kardiol, 79, 183-188.

[2] Karsch, K.R., Haase, K.K., Voelker, W., Baumbach, A., Mauser, M. and Seipel, L. (1990) Percutaneous Coronary Excimer Laser Angioplasty in Patients with Stable and Unstable Angina Pectoris. Acute Results and Incidence of Restenosis during 6-Month Follow-Up. Circulation, 82, 1849-1859. http://dx.doi.org/10.1161/01.CIR.81.6.1849

[3] Sanborn, T.A., Bittle, J.A., Hershman, R.A. and Siegel, R.M. (1991) Percutaneous Coronary Excimer Laser-Assisted Angioplasty: Initial Multicenter Experience in 141 Patients. JACC, 17, 169B-173B. http://dx.doi.org/10.1016/0735-1097(91)90954-8

[4] Margolis, J.R., Litvack, F., Grundfest, W., Eigler, N., Goldenberg, T., Laudenslager, J., Tsoi, D., Wong, S., Segalowitz, J., Hestrin, L., Rothbaum, D., Linneemeier, T., Helfant, R. and Forrester, J. (1989) Excimer Laser Angioplasty: Results of a Multicenter Study. Circulation, 80, II-477.

[5] Srinivasan, R., Casey, K.G. and Haller, J.D. (1990) Sub-Nanosecond Probing of the Laser Pulse Delivered through a Fiber. IEEE Journal of Quantum Electronics, 26, 2279-2283. http://dx.doi.org/10.1109/3.64365

[6] (2013) Melissa Blau: Der Klimawandel. United p.c.-Verlag, 108 p.

[7] Preisack (Blau), M.B., Neu, W., Nyga, R., Wehrmann, M., Haase, K.K. and Karsch, K.R. (1992) Ultrafast Imaging of Tissue Ablation by a XeCl Excimer Laser in Saline. Lasers in Surgery and Medicine, 12, 520-527. http://dx.doi.org/10.1002/lsm.1900120511

[8] Hartmann, J.M. and Boulet, C.J. (2011) Molecular Dynamics Simulations for CO\(_2\) Spectra. III. Permanent and Collision-Induced Tensors Contributions to Light Absorption and Scattering. Chemical Physics, 134, 184-312. http://dx.doi.org/10.1063/1.3589143

[9] Calder, N., Svensmark, H. And Böttinger, H. (2008) Sterne steuern unser Klima: eine neue Theorie zur Erdewärmung.
[10] Calogovic, J., Albert, C., Arnold, F., Beer, J., Desorgher, L. and Flueckiger, E.O. (2010) Sudden Cosmic Ray Decreases: No Change of Global Cloud Cover. *Geophysical Research Letters*, 37, Article ID: L03802.

[11] Yau, M.K. and Rogers, R.R. (1989) Short Course in Cloud Physics. 3rd Edition, Butterworth-Heinemann, 302 p.
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