Determination of the Mean Free Path Length of Quantum/Waves and Total Emissivity of the Carbon Dioxide Considering the Molecular Cross Section of the Carbon Dioxide.

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Abstract:

Through the application of astrophysical formulas, the mean free path length of a Quantum/wave stream leaving the surface of the Earth to the outer space before it has collided with a molecule of carbon dioxide and its total emissivity are calculated. The output of this algorithm indicates a value of about 33 meters. Also calculated is the time taken by a Quantum/wave to exit the atmosphere after it has collided with a molecule of carbon dioxide — which is ~4 milliseconds (ms).

Introduction:

Carbon dioxide (CO_2) is vitally important molecule for life on Earth. Carbon dioxide molecules are taken in from the atmosphere by photosynthetic organisms which employ them to build more complex substances that are used for storing the energy transferred from the quantum/waves to the molecules of chlorophyll.

The current assessment demonstrates that CO_2 is so well dispersed throughout the bulk volume of the atmosphere that its efficiency for capturing quantum/waves emitted from the surface is extremely low.

The objectives of this article are to demonstrate that the mean free path length of the Quantum/wave stream does not significantly change the total emissivity of the CO_2 and that the time taken by a Quantum/wave to exit the atmosphere to space, without colliding with a molecule of CO_2, is extremely low.

Methodology

I have introduced the molecular cross section of the carbon dioxide σ_{CO2mol}, in which case a value for n, calculated from the molar density of the carbon dioxide and the number of molecules per mol of the substance was demanded to make the most accurate solution.

Procedure

Preliminary Data:

The density of the gas carbon dioxide in the atmosphere is obtained by the following formula[7]:

$$\rho_{CO_2} = \frac{(12.187 \ * \ Molar\ mass\ of\ CO_2 \ * \ volumetric\ fraction\ of\ CO_2)}{(276.69\ K)} = 756\frac{mg}{m3}$$

Where 12.187 is the molar mass of elemental carbon, molar mass of carbon dioxide is 44.01, and the volumetric fraction of CO2 is 390 ppmV and 276.69 K is for temperature.

To introduce this value into the formula that I will describe below, I made use of the following magnitudes:

$$\rho_{CO_2} = 756\frac{mg}{m^3} = 0.756\frac{g}{m^3} = 7.56\ x\ 10^{-7}\frac{g}{cm^3}$$

7.56 x 10^-7 *g/cm*^3 is the density of the atmospheric carbon dioxide in the atmosphere obtained from the following calculation:

$$\rho_{CO_2} = \frac{12.187\ of\ C^{12} * \ MM_{CO_2} \ * \ MF_{CO_2}}{T_{abs}}$$

Where 385 *ppmV* is MF_{CO2}, 44.01 are for MM_{CO2} and 276.69 *K* is T_{abs}. You can make your own calculations at *LENNTECH* [(7)], calculator online.

$$Mass\ of\ CO_2\ in\ 1\ cm^3 of\ air = 7.56\ x\ 10^{-7}\frac{g}{cm^3} * 1\ cm^3 = 7.56\ x\ 10^{-7} g$$

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$Avogadro's\ number = 6.02 \times 10^{23}\ molecules/g$ (Avogadro's number has not units, however, when it is introduced like a constant it is expressed as $6.02 \times 10^{23}\ molecules/mol$ or $6.02 \times 10^{23}\ g/mol$).[3]

The molar Density of gases is calculated by using the following formula:

$$\rho = \frac{Molar\ Mass}{R_{specific} \ * \ T}$$

Introducing Magnitudes for CO_2:

$$\rho_{CO_2} = \frac{44.01\ g}{22261\ cm^3} = 0.001977\frac{g}{cm^3}$$

$$Molar\ mass\ of\ CO_2 = 44.01\ g$$

$$Number\ of\ moles\ of\ CO_2 = \frac{(mass\ in\ 1\ cm^3 of\ air)}{(molar\ mass)} = 7.56\ x\frac{10^{-7}(g)}{44.01\ \left(\frac{g}{mol}\right)}$$

$$= 1.7178\ x\ 10^{-8}\ moles$$

$$Number\ of\ molecules\ of\ carbon\ dioxide\ in\ 1\ g\ of\ CO_2\ = \frac{moles\ *\ Avogadro's\ number}{molar\ mass} * (1\ g)$$

$$= \left(\frac{(1.7178\ x\ 10^{-8}\ moles)\ \left(6.02\ \times 10^{23}\ \frac{molecules}{moles}\right)}{44.01\ g} \right) * 1\ g$$

$$= \ 2.35\ x10^{14}\ molecules$$

Considering the density of CO_2 in the atmosphere, the number of moles of carbon dioxide measured in one cubic centimeter in the atmosphere mass, 1.7178 x 10^-8 *moles* are contained in 7.56 x 10^-7 *g* of carbon dioxide per each cubic centimeter of the current atmosphere.

$$CO_2\ molecule's\ cross\ section\ (\sigma) = \ 5\ x\ 10^{-22} cm^2$$

Determination of the Mean Free Path Length of quantum/waves in the atmosphere before colliding with a molecule of carbon dioxide.

Formula to calculate the mean free path length of quantum/waves before colliding with molecules of CO_2:

$l = m\ /\ (n\ \sigma)$ (*References 1 and 2*).

Where l is for the mean free path length, m is for the mass of the gas measured in one cubic centimeter of air, n is the effective quantum density, and σ is the cross section of a molecule of CO_2 before vibrational dephasing (σ = 5.0 x 10^-22 *cm*^2).

Notice that *n* is the total number of states per volume unit, cubic centimeters. For this case, to obtain the *effective molar density* we must to multiply the number of states per mol by the molar gas density of the carbon dioxide.

Known data:

CO_2 molecule's cross section = 5 x 10^-22 *cm*^2

Mass of CO_2 (m) corresponding to a mass fraction of 390 ppmV= 7.56 x 10^-7 g

The molar gas density of molecular carbon dioxide is obtained by the following formula:

Molar gas $\rho_{CO2} = MM_{CO2}\ /\ MV_{STP}$

Where MM_{CO2} is molar mass of the carbon dioxide and MV_{STP} is the molar volume of any gas at *STP* (22.4 L).

Introducing magnitudes:

Molar gas ρ_{CO2} = 44.01 *g* / 22.4 *L* = 1.9647 g /L = 0.0019647 g /cm^3

The following formula is used to calculate the effective molar density of carbon dioxide per cubic centimeter of air:

$n_{mol} = \rho_{mol} * NM = 2.59308 \times 10^{11}\ g/cm^3$ (Ref. 13)

Where n is the effective density of one mole, ρ_{mol} is molar gas density, *and NM is the number of molecules per mol.*

Known values:

n_{mol} =?

$\rho_{mol} = 0.0019647 \left(\frac{g}{(cm^3\ mol)}\right)$

$NM = 2.35\ x\ 10^{14}\ molecules$

Introducing magnitudes:

$$n_{mol} = \left(0.0019647 \left(\frac{g}{cm^3 mol}\right)\right)\left(2.35\ x\ 10^{14}\ (molecules)\right) = 4.617\ x\ 10^{11}\left(\frac{g}{cm^3\ mol}\right)$$

Therefore, $4.617\ x\ 10^{11}\left(\frac{g}{cm^3}\right)$ is the effective molar density of the carbon dioxide that must be considered for calculating the mean free path length of a quantum/wave crossing the troposphere between collisions with molecules of carbon dioxide.

Determination of the Mean Free Path Length of Quantum/Waves through the Earth's troposphere.

Introducing magnitudes:

$$l = \frac{m}{(n\ \sigma)}$$ (*References 1 and 2*)

$$l = \frac{(7.56\ x\ 10^{-7} g)}{\left(4.617\ x\ 10^{11}\left(\frac{g}{cm^3}\right) * 5\ x\ 10^{-22}(cm^2)\right)} = 3274.8\ cm$$

$$l = 32.75\ m$$

Therefore, the mean free path of the surface quantum/waves stream (l) is 3274 cm, which is the trajectory of a quantum/wave passing through the atmosphere before it collides with a molecule of carbon dioxide.

This means that a quantum/wave shifts about 33 meters to hit onto a molecule of carbon dioxide in the atmosphere.

This distance is well understood if we take into account that as the temperature of the lower troposphere increases during daylight by a highly energized surface quantum/wave stream, the thermal diffusivity of carbon dioxide increases, to be precise, as the temperature increases, the molecules diffuse more quickly into a thermally expanded volume of air.

In consequence, the distance between one molecule of carbon dioxide and another molecule of carbon dioxide is lengthened as the temperature increases. For example, the thermal diffusivity of the carbon dioxide at 255 *K* (-18 °*C* or -0.40 *F*) is 7.83 x 10^{-6} (m^2/s), while at 308 K (35 °*C*, or 95 *F*) is 1.171 x 10^{-5} (m^2/s).[3]

Determination of the time a quantum/wave takes to leave the atmosphere of the Earth towards space after colliding with molecules of CO_2:

Formula for obtaining the time taken by a Quantum/wave to leave the Earth's atmosphere after colliding with molecules of CO_2:

$$t = \frac{(r^2)}{(l * c)} \qquad (References\ 1\ and\ 2)$$

Known Data:

$r_{trop} = 700000\ cm$

$l = 5831\ cm$

$c = 2.99909301\ x\ 10^{10} \left(\frac{cm}{s}\right)$

Introducing Magnitudes:

$$t = \frac{r^2}{(l*c)} = \frac{\left(4.9\ x\ 10^{11}(cm^2)\right)}{\left[3274.8\ cm * 2.99909301\ x\ 10^{10}\left(\frac{cm}{s}\right)\right]} = 0.0049\ s$$

$t = 0.0049\ s$

The result indicates that it takes quantum/waves approximately 5 *ms* (*milliseconds*) to cross the troposphere from the surface of the Earth after colliding with molecules of CO_2.

In contrast, molecules of Water Vapor (H_2O) and solid particles, which are also present in the atmosphere, intercept and absorb the quantum/waves emitted from the surface of the Earth long before they could collide with any molecules of carbon dioxide and before the molecules of carbon dioxide interact with other molecules:

Determining the Total Emissivity of the Atmospheric Carbon Dioxide as from the Crossing Time Lapse that a Quantum/Wave takes to leave the Troposphere

The formula to calculate the total emissivity of fluids, plasma or free electrons is as follows:

$$\varepsilon = \frac{\left(1 - e^{t*\left(-\frac{1}{s}\right)}\right)}{\sqrt{\pi}}$$

Where ε is the total emissivity and t is the crossing time lapse of a quantum/wave.

Known values:

$t = 0.0049\ s$

Introducing magnitudes:

$$\varepsilon = \frac{\left(1 - \left(e^{0.0049\ s\ *\left(-\frac{1}{s}\right)}\right)\right)}{\left(\sqrt{3.1415\ ...}\right)} = 0.0028$$

This result coincides with the result obtained from considering the partial pressure of the carbon dioxide and its instantaneous temperature in the atmosphere; additionally, it coincides with the total emissivity obtained from the experiments conducted by H. C. Hottel[8], B. Leckner[9], M. Lapp[10], C. B. Ludwig[11], A. F. Sarofim[12] and their collaborators[11, 12]

CONCLUSIONS:

The results obtained by experimentation coincide with the results obtained by applying astrophysics formulas. Therefore, both methodologies are reliable to calculate the total emissivity of any gas in any planetary atmosphere.

At an average density, the atmospheric water vapor allows quantum/waves to cross the troposphere to the tropopause in 0.0245 *s*, i.e. 2.45 *cs* (centiseconds). By comparing the ability of water vapor to avoid that quantum/waves escape towards the outer space (0.5831 *s*) with the ability of CO_2 (0.0049 *s*), I can affirm that the role of CO_2 on warming the atmosphere or the surface is not possible according to Physics Laws.

The water vapor is five times more efficient on intercepting quantum/waves than the carbon dioxide. Consequently, the absorption of thermal energy in the atmosphere is highly influenced by water vapor. The carbon dioxide has no role on keeping warm the Earth.

According to other parameters, like the conductive heat transfer in the surface and subsurface materials and the convective heat transfer in the atmosphere, I conclude that the main role of the atmospheric gases is to distribute the thermal energy on a natural trend to homogenize the temperature of the Earth.

Alternatively, because of its efficiency to take thermal energy from the surface, the atmosphere works as a coolant of the surface, not as a warmer. This cooling effect of the atmosphere on the surface is evidenced during daytime and corroborated during nighttime without difficulty.

Considering also that the carbon dioxide has a lower total emissivity than the water vapor, I conclude that the carbon dioxide has not an effect on climate changes or warming periods on the Earth.

The low thermal diffusivity of carbon dioxide makes of it to be an inefficient substance to adjust its temperature to surrounding temperature. Consequently, the carbon dioxide can never reach the thermal equilibrium with respect to other molecules of the air.

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