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NOTES ON AN EQUATION FOR RAINDROP EMBRYOS

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ABSTRACT: In studying the process of rain formation in clouds, this has been a total mystery until nucleation of raindrops were understood mathematically. These days, cloud chemistry has made real inroads to access this problem. In this article, the author wondered how much of a constant the exponent is in the classical nucleation rate J = C exp (D) by comparing experimental data with the theory. Also, because rainfall is absolutely essential to life, we mention how The Bible connects rain with the end of war. Indeed, the author was able to prove that data and theory both show that D ≈ - 50 for the equation presented in Young (1993).

KEYWORDS “end of time” “classical nucleation theory” rainbow “Kelvin equation” “rain formation”

I. INTRODUCTION

The third world war will not take place and this can be proved by Scripture. Just after the Noahic flood, God sends his bow on the clouds so that He will never again destroy man. (GENESIS 8:21-22 and 9:13) In particular, there, God said, “As long as the earth lasts, seed time and harvest...shall not cease.” This means that nuclear winter won’t happen! Obviously the farmer needs sun and rain for the crops. Thus, we are interested in rain embryos, which are the critical sized water nuclei that are able to get past the energy barrier to become life-giving raindrops falling from clouds. Classical nucleation theory, which had its real start in Josiah Willard Gibbs, has done well in predicting phase change for liquids (Blander/Katz, 1975) and has been useful in predicting the nucleation rate, J, for rain embryos (Young, 1993), page 40 (3.36). J is of the form J = C exp (D) and we endeavor to get a handle on D near zero degrees centigrade, a typical temperature for a cloud.

$$J = 4\alpha_c/N_L(\sigma/2\pi m)^{1/2}(e/kT)^2\, S^2\, \exp[-16\pi\sigma^3/3(kT)^3(N_L \ln S)^2] \qquad (1)$$

Young (1993) has the Kelvin equation, page 30 (3.15), which has S, the saturation ratio, later defined on page 39 here (3).

II.RESULTS

In order to use the Kelvin equation, one has to have the number of water molecules in the critical cluster. Young (1993) maintains that at 0 degrees Centigrade there are 63 = g molecules of water in the critical cluster for $J = 10^3$ events/cm^3-sec, page 41, so that is what the author used in calculating ln S for -8, 0, and +10 degrees Centigrade.

$$g/N_L = 4\pi r^3/3 \qquad (2)$$

Eq. (2) is used to calculate r, the critical drop radius, and $N_L = 3.3425 \times 10^{22}$ molecules/gm, number density for water at 0 degrees Centigrade. Eq. (3) is the Kelvin equation from Young (1993), with definition of S, page 39. Using (2), one gets $r = 0.7663 \times 10^{-7}$ cm and the density of water is taken to be 1 gm/cm^3 (incompressible).

$$\ln S = 2\sigma/N_L kTr \qquad (3)$$

$$D = -16\pi\sigma^3/3(kT)^3(N_L \ln S)^2 \qquad (4)$$

The object is to see if indeed D = constant by taking g = 63: 1) directly calculating S, using (3) and σ from CRC 66^{th} Ed. (1985-86) page F-32 and 2) taking experimental S for the three temperatures from Young (1993), Fig. 3.7 graph page 41. The answer is yes as D(calculated) = - 49.2 ± 2.0 and D(from data) = - 48.2 ± 1.2. The details will be given in DISCUSSION. In Young (1993) p. 40 we read, "Thus it is the exponential term in the nucleation equation that is tested by these observations and not the pre-exponential factor." Young is saying that effectively |dlnC/dD| is small.

III. DISCUSSION

Fig. 3.7 has curves for J at 1, 10^3 and 10^6 events/ cm^3-sec for experimental data of the raindrop nucleation rate, so the author took the geometric mean 10^3 curve. The Y axis is S and the X axis is T. Here is a complete table of what the author did. This is only in the vicinity of zero degrees Centigrade.

T ^oC	σ ergs/cm^2	S(calculated)	S(from graph)	D(from S calculated)	D(S from graph)
- 8	77.0	5.1672	5.6	- 51.7	- 47.0
0	75.6	4.784	4.9	- 49.3	- 47.8
+10	74.22	4.4035	4.2	- 46.7	- 49.8

In a Max Planck Institute URL, REFERENCE [4], the critical cluster is supposed to be less than 100 molecules, similar to what is taken in this article 63 molecules of water in clouds. The author performed some research from 1980-83, Jennings/Middleman (1985), on the limit of superheat in polymer solutions with the theory substantially wrapped up in Jennings (2020).

Jennings (2020) uses Blander/Katz's (1975) nucleation equation of the characteristic form J = A exp (K) and Jennings was able to calculate K exactly, K = - 64.56 for 10 different solvents, 7 non-polar and 3 polar. K corresponds to D in this study. A corresponds to C. The author here has arrived at a value for D from reading S off a graph or by calculating S from the Kelvin Eq. |dlnA/dK| is small.

IV.CONCLUSION

The better rainfall is understood, the better off man is in providing for human nutrition. This paper may not be highly original but is more of a mini-review on the topic. We hope that God, in His infinite knowledge and provision will bring history to its close and be our God until the bitter end.

SELECTED NOMENCLATURE

A prefactor
C prefactor
D exponent
g H2O molecules in cluster
J nucleation rate
k Boltzmann constant
K exponent
N_L number density of H2O
r critical drop radius
S saturation ratio, either from experiment or calculation
T temperature Kelvin
σ surface tension of H2O against air

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