

On The Nature of Ring Patterns in Ice Crystals of Hailstones at Doom Dooma (27.40N, 95.30E) on March 17, 2016

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ABSTRACT: In the present work we have reported for the first time the ring patterns in the ice crystals procured from the hailstones. The measurements have been made from the photographs of five different samples. We believe that the ring patterns will give valuable information on the process of ice nucleation. We have also measured the intensity patterns of the rings with the help of a software (imageJ).

KEYWORDS: Ice Crystals of Hailstone, Ring Patterns, Ice nucleation.

I. INTRODUCTION

Hailstones though occurs rarely is a part of weather which is the atmospheric conditions at a particular time and space. Weather is usually assessed in terms of temperature, wind, cloud cover and precipitations such as rain and snow. Cloudy wet changeable weather is common in low pressure zones with rising unstable air. Such conditions occur at temperature latitudes, where warm air meet cool air along the polar fronts. Here spiralling low pressure cells known as depressions often form. A depression usually contains a sector of warmer air, beginning at a warm front and ending at a cold front. If the two fronts merge forming an occluded front, the warm air is pushed upwards.

There are different types of occluded front. Warm occlusion – when advancing cold front rises up over warm front. Cold occlusion where cold front overcruts warm front. In rising air rain from clouds not reaching freezing level we have also different forms of precipitation. Water droplets less than 0.5mm in diameter fall as drizzle. Water droplets coalesce to form rain drops 0.5 – 5mm in diameter. Again in rising air in rain and snow from clouds reaching freezing level we have coalesced water droplets fall as rain. Snowflakes grown from ice crystals fall as snow. In hail vertical air currents toss frozen water droplets up and down and alternate freezing and melting builds up layers of ice and ice falls as hailstones.

It is worthwhile to note that Sir C.V. Raman took active interest in research in weather several decades ago [1]. Reports of hailstones of different types and ice falling from sky are available in internet without much detail about the research being carried out in the area. In some cases they have been termed as paranormal phenomena. One of the most mysterious, yet quite important problems confronting atmospheric and cloud physics is the question of how ice crystals are formed in the atmosphere. This problem has occupied the attention of researchers during past many decades [2-6]. In fact there are innumerable references indicating the work related to the mechanism of atmospheric ice formation around nucleating agents. The work of Vonnegut[4] performed on silver iodide in 1947 did much to advance the idea that ice crystal formation proceeds principally on the surface of an ice-like solid nucleus. A comprehensive review on the process of ice nucleation has been made by G. Vali [7] who has successfully analysed the process of ice nucleation

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in lower tropospheric clouds. The formation of large crystals ($\approx 100\mu\text{m}$) near the tropical tropopause has also been investigated by Jensen et al [8]. In the present work we report an analysis of the ring patterns observed in the ice crystals of hailstones at Doom Dooma (27.40N, 95.30E) on March 17, 2016. Survey of the available literature indicates that such types of ice crystals in hailstones exhibiting ring patterns have not been reported earlier. We thus reasonably believe that this is the first report of its kind.

II. EXPERIMENTAL

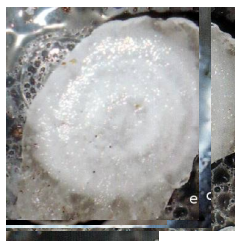
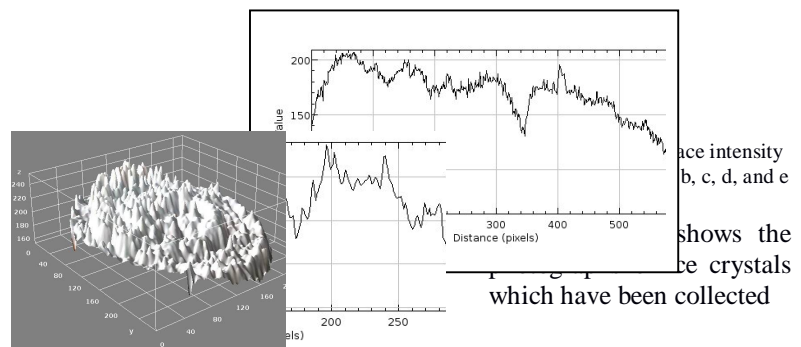
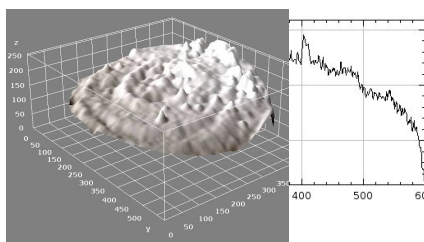
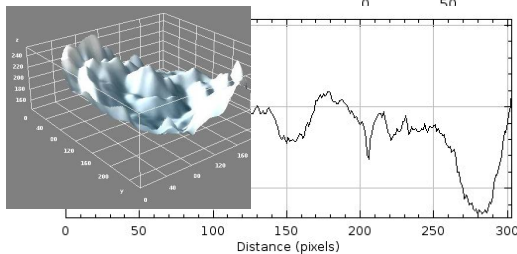
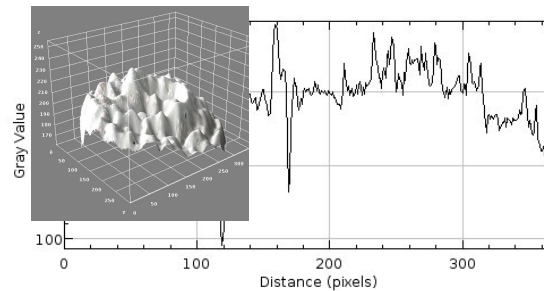
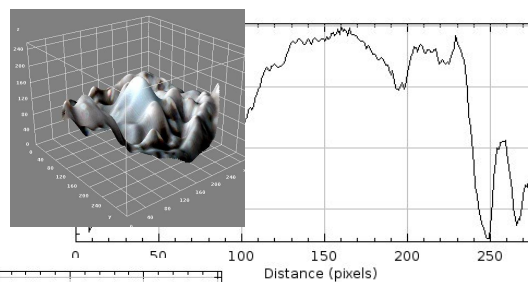


Fig. 1. (a,b,c,d,e) shows the photographs of ice crystals which have been collected for the purpose of study



for the purpose of study. An usual camera available with a mobile phone (Samsung Galaxy Core-2) has been used. The size of the stones ranges from 5mm to 25mm. The salient feature of all the samples is that they exhibited concentric elliptical rings (in some cases completely circular) of alternate white(bright) and dark intensity. In all the samples the centres of the rings always dark. The findings are measured for different rings as a distance from the centre and they are shown below in Table-1 for five different samples. The measurements are made with the help of a millimetre scale from the actual photographs with an accuracy of $\pm 0.2\text{mm}$. We may indicate here that the distance has been measured along the semi major axis in case of elliptical rings. The intensity distribution of the rings observed has been measured from the actual photographs using software known as imageJ. Both linear and surface plots are exhibited in Fig 2.

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Table 1: Distances of the rings from the centre in millimetres

SAMPLE 1 (Circular)			SAMPLE 2 (Elliptical)		
Ring No.	Radius (mm)	Ratio of successive rings	Ring No.	Radius	Ratio of successive rings
1	2		1	3.1	
2	3.4	1.70	2	5.1	1.64
3	5.6	1.64	3	9.0	1.76
4	8.4	1.50	4	14.0	1.5
5	13.5	1.61			

SAMPLE 3 (Elliptical)			SAMPLE 4 (Elliptical)		
Ring No.	Radius (mm)	Ratio of successive rings	Ring No.	Radius	Ratio of successive rings
1	1.5		1	1.3	
2	2.5	1.66	2	1.8	1.38
3	4.2	1.68	3	3	1.66
4	6.3	1.50	4	5	1.66
			5	8	1.60

SAMPLE 5 (Elliptical)		
Ring No.	Radius (mm)	Ratio of successive rings
1	2.4	
2	3.8	1.58
3	6.5	1.71
4	10.4	1.60
5	16.6	1.60
6	22.0	1.32

III. RESULTS AND DISCUSSION

We now proceed to sum up the results which have emerged in this work. Let us first consider the data exhibited in table 1. It is worthwhile to remark that the rings correspond to the cross sectional view of the ice crystals which are observed during the period of the melting and therefore it is reasonable to believe that the bigger solid samples just at the time of striking the surface possess a large number of rings, (for a sample of size of 10cm the number of rings may be around 50). The formation of rings which is presumably represent a density fluctuation, in some specific manner. The formation of these rings are in some ways analogous to the process of epitaxy which consists of the growth of one crystal in one or more particular orientations on a substance of another with a near geometric fit between the respective networks which are in contact [7,8]. If a crystal has a pattern or organization of ions that is regular and predictable, this structure is called a lattice. The surface lattice of one crystal may resemble very closely to that of a second but different type of crystal. Depending of the closeness of resemblance, the second type of crystal may be able to grow on the surface of the first.

From the data included in Table 1 it will be seen that if we take the ratio of the two consecutive terms in the distances of the rings from the centre the ratio seems to remain constant. This is about 1.6 which is close to the so-called “divine number” of the Fibonacci series. It is to be noted that Fibonacci numbers are the sequence of numbers defined by the linear recurrence equation

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$$F_n = F_{n-1} + F_{n-2} \dots \dots \dots (1)$$

with $F_1 = F_2 = 1$. As a result of the definition it is convenient to define $F_0=0$. The Fibonacci numbers for $n=1,2,3, \dots$ are 1,1,2, 3,5,8, 13,..... These numbers seem to appear in nature in numerous cases. There are few other characteristics of the Fibonacci series which are interesting to note. As for instance learning aside few small terms if we take the ratio of two consecutive terms then the ratio always remains the same and it is equal to 1.618. This number is known as the divine number. In our present case it may be just a case of coincidence.

IV. SUMMERY AND CONCLUSIONS

In the present work we have reported for the first time the ring patterns in the ice crystals procured from the hailstones. The measurements have been made from the photographs of five different samples. We believe that the ring patterns will give valuable information on the process of ice nucleation.

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