On The Nature of Ring Patterns In Ice Crystals of Hailstones: A Signature of Global Warming

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***Abstract*— In the present work we report for the first time the ring patterns in the ice crystals procured from hailstones at Doom Dooma (27.40N, 95.30E) on March 17, 2016 and April 9, 2017. We have measured the intensity patterns of the rings with the help of a software (ImageJ). Since the ring patterns have been observed in the ice crystals of hailstones only in recent years, it is reasonable to believe that they will give valuable information on the process of ice nucleation and possibly on global warming**

***Index Terms*—Ice, Crystal, Global warming.**

I. INTRODUCTION

Hailstones though a rare phenomenon in a part of the weather at the particular location and time. Weather is usually assessed in terms of temperature, wind, cloud 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 meets cool air along the polar fronts. Here spiralling low pressure cells known as depressions often form and the 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 upward. There are different types of occluded front. In raising air rain from clouds not reaching freezing level we have also different forms of precipitations. Water droplets less than 0.5mm in diameters fall as drizzle. Water droplets coalesce to form rain drops 0.5mm in diameter. Again in raising air in rain and snow from clouds reaching freezing level we have coaleasced 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 worthy of remark that Sir C.V. Raman took active interest in weather research several decades ago[1]. One of the most mysterious, yet quite important problems which concern atmospheric and cloud physics is the question of how ice crystals are formed in the atmosphere. This problems has occupied the attention of researchers during past many decades [2-6]. The work of Vonnegut [4] performed on silver iodide in 1947did 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 Vali [6] who has successfully analysed the process of ice nucleation in lower tropospheric clouds. The formation of large crystals (~100µm) tropical tropause has also been investigated by Jensen et. al. [7]. In the present work we report for the first time the ring patterns in the ice crystals proccured from hailstones Doom Dooma (27.40N, 95.30E) on March 17, 2016 and April 9, 2017. The report of the ring patterns in ice crystals of hailstones on March 17, 2016, has already appeared in a recent publication [8]. It is worthwhile to remark that the same phenomenon repeated after one year, on April 9' 2017, at the same place. In this connection we would like emphasize that hailstones frequently occur during these periods at several places in north-east India. But photographs of the ice crystals could not be procured except in one case where photographs of the ice crystals in hailstones were exhibited in a national daily[9] showed ring patterns. It is true that ice crystals in hailstones are common phenomena ate these places during March-April, but ring patterns in ice crystals are of very recent origin only. Survey of the available literature indicates that such types of ice crystals exhibiting ring patterns have not been reported earlier.

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II. EXPERIMENTAL:

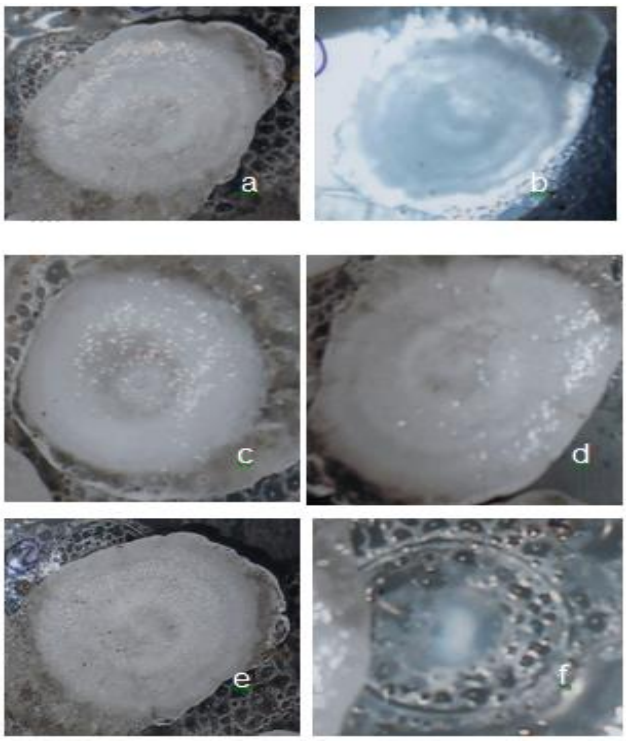

Fig 1 (a,b,c,d,e,f) The ice crystals in hailstones on March 17, 2016

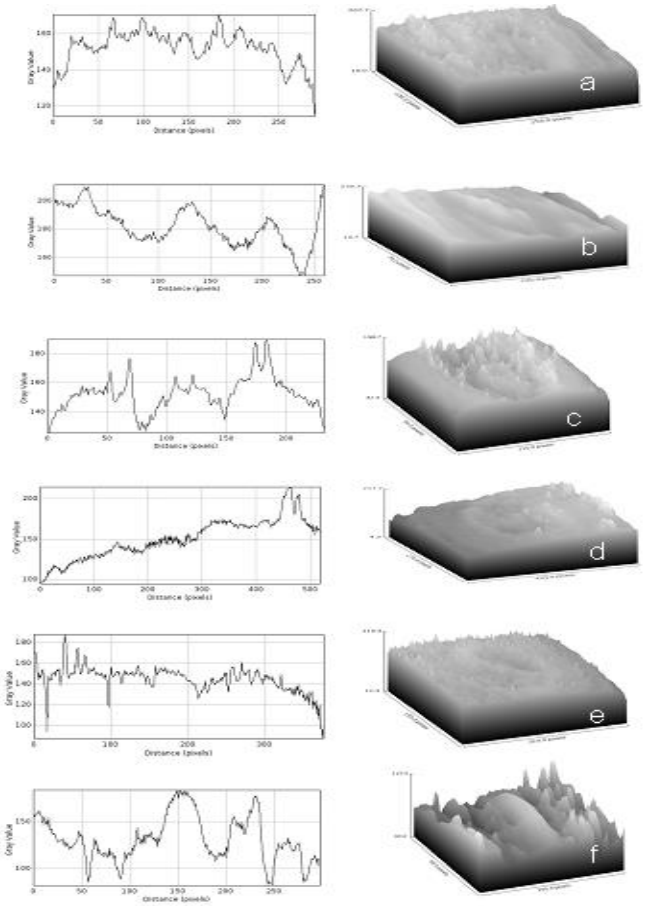

Fig 2 (a,b,c,d,e,f) intensity distribution of the rings.

The size of the stones ranges from 5mm to 25mm. The salient features of all the samples is that they exhibited concentric elliptical rings (in some cases completely circular) of the alternate white (bright) and dark intensity. Similarly Fig 3 (a,b,c,d,e) shows the photographs of the ice crystals which have been procured for study of April 9, 2017. The crystals which have been procured for study in the year 2016 and 2017 are identical.

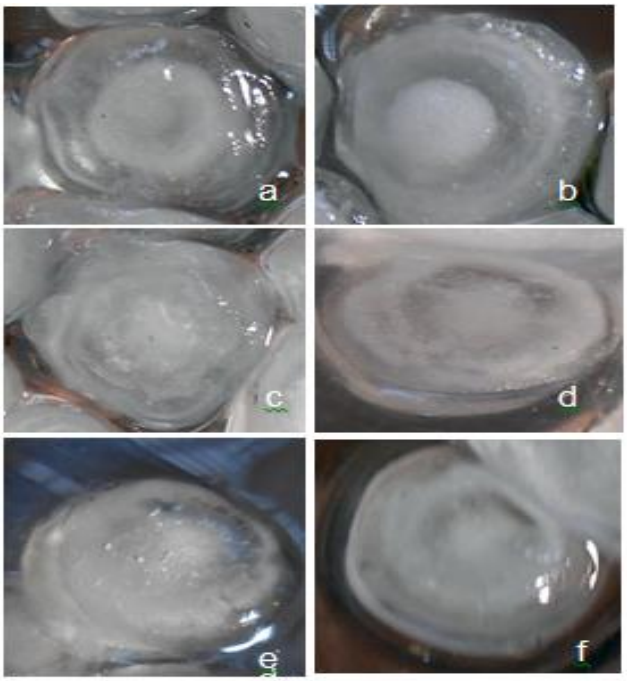

Fig 3 (a,b,c,d,e,f) The ice crystals in hailstones on April 9, 2017.

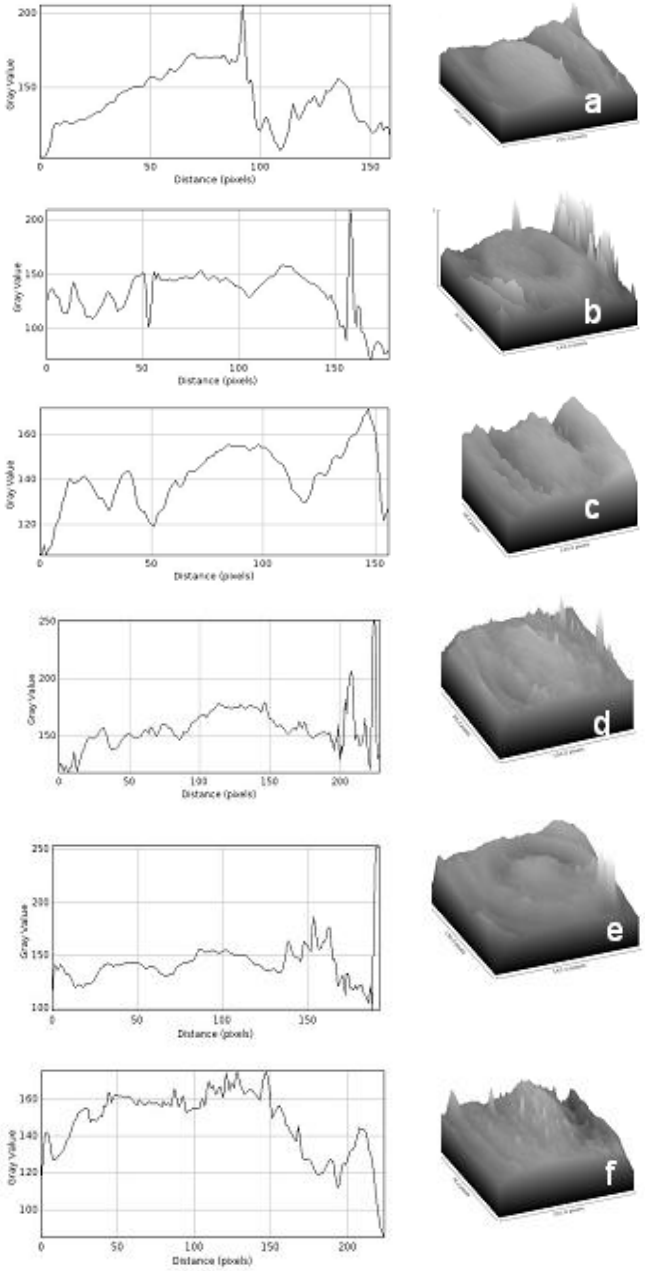

Fig 4 (a,b,c,d,e,f) Intensity distribution of the rings of the ice crystals in hailstones on April 9, 2017

For all the samples the centres of the rings are always bright. The findings are measured for different rings as distance from the centre (taken arbitrarily from the photographs) and they are shown in Table 1 and Table 2 for five different samples each procured for study in two successive years.

Table 1: Distance of rings from the centre (ice crystals in hailstones on March 16, 2016)

Sample 1 (circular)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	2	
2	3.4	1.70
3	5.6	1.64
4	8.4	1.50
5	13.5	1.61

Sample 2 (elliptical)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	3.1	
2	5.1	1.64
3	9.0	1.76
4	14.0	1.5

Sample 3 (elliptical))		
Ring No.	Radius(mm)	Ratio of successive rings)
1	1.5	
2	2.5	1.66
3	4.2	1.68
4	6.3	1.50

Sample 4 (elliptical)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	1.3	
2	1.8	1.38
3	3	1.66
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

Sample 6 (circularl)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	6	
2	9.5	1.58
3	15	1.57
4	17	1.13
5	19	1.12

Table 2 Distances of the rings from the centre (in mm). (ice crystals in hailstones on April 9, 2017).

Sample 1 (circular)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	3	
2	5	1.66
3	7	1.40
4	9.3	1.32

Sample 2 (elliptical)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	6	
2	9	1.50
3	13	1.44
4	18	1.38

Sample 3 (elliptical))		
Ring No.	Radius(mm)	Ratio of successive rings)
1	5.5	
2	9.0	1.64
3	13.0	1.44

Sample 4 (elliptical)		
Ring No.	Radius(mm)	Ratio of successive rings)
1	4.5	
2	8.0	1.77
3	12.5	1.56
4	16.2	1.32

Sample 5 (elliptical))		
Ring No.	Radius(mm)	Ratio of successive rings)
1	7	
2	9	1.28
3	13	1.44
4	18	1.38

Sample 6 (circular))		
Ring No.	Radius(mm)	Ratio of successive rings)
1	5.5	
2	8.8	1.6
3	11.5	1.3
4	13	1.1

The measurements are made with the help of a millimetre scale from the actual photographs with an accuracy of ±0.2 mm. The intensity distribution of the rings observed has been measured from the actual photographs using a software known as ImageJ. Both linear and surface plots are exhibited.

III. Result and Discussions:

It is now worthwhile to sum up the results which have emerged in this work. It is worthy of 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 they belong to bigger solid samples which exist before striking the ground. For a sample of size 5cm the number of rings may be observed

around 25. The formation of the periodic rings is presumably due to the density fluctuation in some specific manner. As indicated earlier, in hailstones vertical air current toss frozen air droplets up and down and alternate freezing and melting builds up layers of ice and ice falls as hailstones. The ring formation originates as a result of this. At this stage we would like to indicate that the ring formation in ice crystals from hailstones is of recent origin and it followed after whirlwind in the atmosphere. The phenomenon may not be entirely termed as local as it depends on atmospheric conditions elsewhere. We may speculate here that the frequent occurrence of ring formation in ice crystals is one of signatures of global warming.

It will be seen from the data exhibited in Table 1 and Table 2 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. The ratio is about 1.6 (neglecting few cases) which is close to the "devine number" of the so called Fibonacci series. We may note here that Fibonacci numbers are the sequence of numbers defined by the linear recurrence equation

$$F_n=F_{n-1}+F_{n-2}$$

with $F_1=F_2=1$. As a result of the definition it is convenient to define $F_o=0$. The Fibonacci numbers for n=1,2,3,.....are 1,1,2,3,5,8,13.....These numbers seem to appear in Nature in numerous cases. One of characteristics of the Fibonacci numbers is that, leaving aside few small terms, then the ratio remains the same and it is equal to 1.618. This number is known as devine number.

IV. Conclusion:

In the present work we have reported for the first time the analysis of the ring patterns in the ice crystals procured from hailstones in two consecutive years. We believe that such types of ice crystals will give valuable information about the process of ice nucleation possibly in global warming.

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