SocioBrains

ISSN 2367-5721, JOURNAL HOMEPAGE: WWW.SOCIOBRAINS.COM

INTERNATIONAL SCIENTIFIC REFEREED ONLINE JOURNAL WITH IMPACT FACTOR

ISSUE 67, MARCH 2020

FRACTAL BEHAVIOR OF THE DICHEV'S RINGS IN WATER

Abstract: A fractal analysis was performed to the newly established phenomenon called Dichev's rings. The invention is related to the formation of rings from ferromagnetic fine dust put on the water surface. The floating effect is due to the water surface tension. When approaching a permanent magnet located under the water, the ferromagnetic dust formed the

Dichev's rings. This simple experiment is performed on a special devise and is repeatedly checked many times. What is important to mention are the fractal properties of the formed circular structures and their behavior in different experimental conditions. The resulting fractal dimension of about 1.70 – 1.71 is an indicator of strongly expressed nonlinear behavior of the ferromagnetic particles in water during the experiment.

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Keywords:
Dichev's rings, fractal analysis, water, experiment

INTRODUCTION

In 2002 on 10th December the Patent Survey of Republic of Bulgaria gave the Diploma No 16 for original invention to Christo Ivanov Dichev entitled "Dichev's rings", named to their inventor (Diploma, 2002). The short description of this invention states: "Putting the ferromagnetic dust from small sized particles in the water over any pole of permanent magnet located close to the water, always appeared Dichev's rings oriented concentrically, not known and not described up to this moment from any scientists, laboratory or institution." The invention was published in a small book (Dichev, 2016) entitled "Nonpopular experiments in Physics" and can be realized in any school laboratory and entered in some school programs in Bulgaria.

Among some strange properties (such as no matter N or S pole of the magnet is under water up, the profile of the magnet surface – circular, rectangular or elliptic, etc.), we discovered that many pictures of the Dichev's rings look as geometric fractals. The fractal analysis preformed on different conditions with different parameters of the experimental data support clearly the conclusion about fractal properties of the Dichev's rings. Earlier studies by other authors (Falconer, 2003; Jurendic and Pavuna, 2012) confirm the fractal behavior of water molecules within water vortices. These results, as well as the new evidence for fractal geometry of the water rings within the Dichev's experiment, provide a good basis for further in-depth studies in this direction.

METHODOLOGY AND METHODS

Description of the experiment

The experimental device is presented on Fig.1. It consists of a stable bar on which the main elements of the device are attached. There is a plastic box (for water), under it is placed the movable vertically rotating screw on which the magnet is fixed. Thus the changeable distance between the water surface and the magnet is provided. The experimental device is very simple, can be reproduced in any school physics laboratory, even at home (Dichev, 2016)

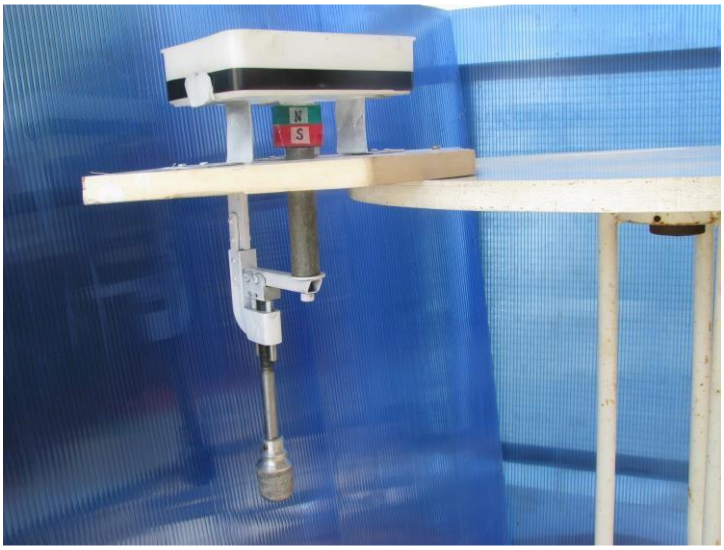

Fig.1. The experimental device

The plastic box is pouring with water from the home tube. The water level is between 10 to 30 mm (in our case 12 mm). The temperature of the water is 18°C, but can varies. The magnet is neodymium type, cylinder with diameter of 25 mm and length of 30mm. The magnetic pole does not matter (N or S). The ferromagnetic material (fine dust from ferrites used in electronics) is put very carefully on the water surface. The water surface tension keeps the dust on the surface. When approaching magnet to the bottom of the plastic box, the typical fractal structure of the rings appeared. The distance between the magnet and the water surface is changed (in our case between 28 and 35 mm). The larger distances formed the fractal structures (in our case the approximate diameter of the spot of the structures is about 50-55 mm). When distance is decreasing (in our case at h=28 mm and less), the material formed classical fractal stable structures, starts drown down and the structures are destructed. The conditions of the experiment depends of many factors as water temperature (this changes the surface tension) the strength of the magnet, the size of the ferromagnetic grains, etc.

The experiment shows – the visual fractal structure of the Dichev’s rings is stable in a certain experimental conditions: distance interval (in our case between 34 mm and 28 mm - i.e. at distance interval of the magnet shift of about 6 mm); static magnet; constant water temperature. To prove the fractality of the observed structures the fractal analysis was performed.

Box-counting method for fractal dimension estimation

In this study, the fractal analysis of the Dichev's rings was performed using well known „box-counting” method (Mandelbrot, 1982; Hirata, 1989). In this improved method the image pixels are covered with square boxes and software counting the total number of boxes containing any data. In this way, the fractal dimension (D) is determined based on the formula (Mandelbrot, 1977):

$$D = \lim_{r \to 0} \frac{\log(N(r))}{\log(1/r)} \qquad (1)$$

where N (r) is the number of boxes that contain at least one piece of data, and r is the boxes length (size).

RESULTS AND DISCUSSION

The results regarding the fractal structure of Dichev's rings are presented graphically in Figures 2 and 3. The brief discussion below brings out the main interpretations about this.

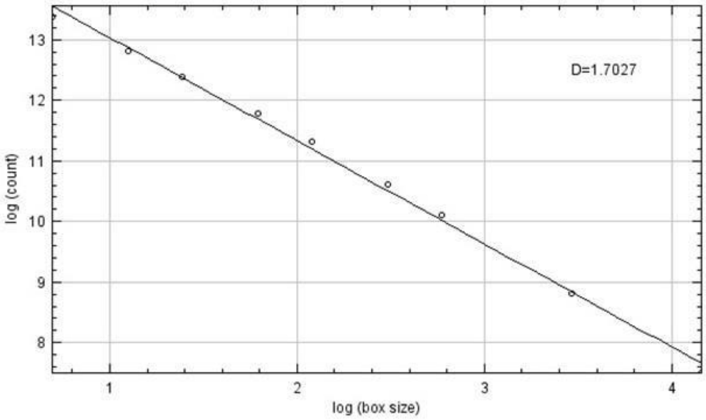

Fig.2. The original picture as a result of the experiment (above). Conditions: d=53mm; h=34 mm (i.e. the magnet is far at this distance from the water surface). The fractal dimension calculated by box-counting method (down).

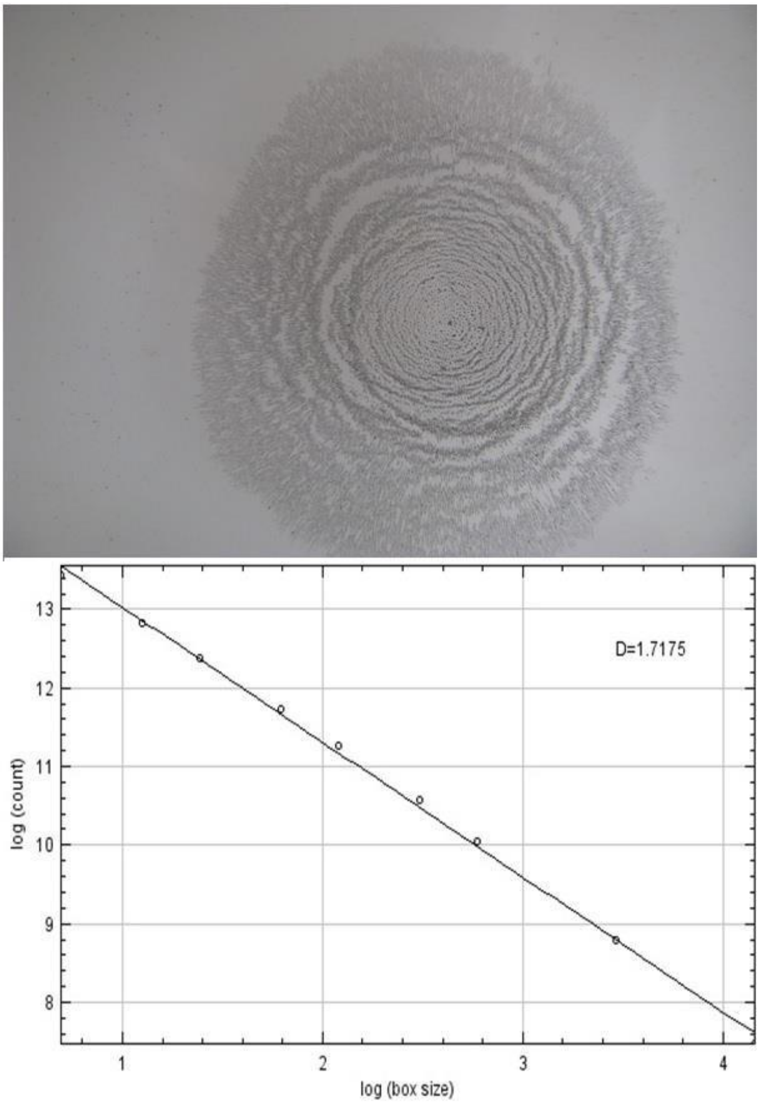

Fig.3. The original picture (d=53 mm; h=33 mm) (above) and the fractal dimension calculated by box-counting method (down).

The presented results are indicative examples of all varieties of the distances between 35 and 28 mm. As we explained earlier the experiment varies with the distance between the water surface and the magnet pole. The results obtained confirmed that the Dichev's rings formed the stable fractal structures with an average fractal dimension about 1.70 to 1.71.

The experiments have been repeated in different conditions - water level and temperature change, different types of magnets, different materials of the ferromagnetic dust, etc. The repeatability and stability of the results are confirmed by the formation of stable fractal structures with approximate stable fractal dimensions. This means – the fractal structure of the Dichev's rings is stable in a certain distance interval (in our case between 34 mm and 28 mm - i.e. at distance interval of about 6 mm). The structures are stable in stable conditions. If the distance between the rings and magnets is changed (decreasing) the fractal structure formed spiral movement to the bottom of the box (one more strange peculiarity) and in a few moments disappear (the particles went to the bottom of the box).

In another experiment – the fractal structure is transformed in clear rings with approximately equal distances between them (Fig.4). The observed phenomenon of the performed experiment is very sensitive – relatively small changes in the initial conditions changed the experimental result and created different circular (visually non fractal) structures.

Fig.4. The original pictures of symmetrical ring structures. Conditions: d=38 mm; h=33 mm (left) and d=38; h=34 mm (right)

CONCLUSIONS

The present study confirmed the fractal structure of the ferromagnetic particles forming rings in water within Dichev's experiment. The fractal dimensions show nonlinear behavior of the ferromagnetic particles in their interaction with magnets. The fractal analysis results clearly confirms this claim. Obviously the electromagnetic forces in nature tend to reorganize the particles with which they interact in a clear fractal configuration. The future experiments with some mixtures of the ferromagnetic dust and other substances need extended research in the future.

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*Diploma No 16/10.12.2002 for scientific invention to Christo Dichev. Patent survey of Bulgaria.