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Student's Question of the Day

What is Chaos?

Everyone must have heard the sentence that *science is the study of nature* – once in his or her life. Ironically, after centuries of hard work science had just been able to understand the very basic, ordered and well behaved phenomena of nature. Natural phenomena like formation of clouds, sudden changes in weather, turbulent water trail behind a boat, rising smoke of cigar, beautiful but totally different shapes of leaves, amazingly attractive landscapes, diverse orbits of planets, decay and growth of population of (say) wolves in amazons, sudden crashes of stock markets, unexpected popularity of a political leader, unpredictable behavior of a mathematical function, plate tectonics, heart attack with no apparent cause etc, etc are so assorted, complex and disordered that conventional methods of science had not been able to fully understand and make predictions about such phenomena. We are talking about ending of 19^{th} century and this is the time where *Chaos* makes its appearance.

"Chaos theory (or non-linear dynamics) describes the behavior of certain dynamical systems – that is, systems whose states evolve with time – that may exhibit dynamics that are highly sensitive to initial conditions." [1] The phrase *Chaos* indicates something disordered but in reality it is the other way round. Henri Poincare first discovered *Chaos* in the 1880s, while studying the three body problem [2], although James Yorke was the first one to coin the term *Chaos* while attending a symposium on Chaos in December 1977 at New York academy of sciences (look at the time lag between discovery and recognition). Much of the earlier *Chaos* theory was developed by mathematicians under the name of ergodic theory with contributions from G.D. Birkhoff [3], A.N. Kolmogorov [4], M.L. Cartwright [5], J.E. Littlewood [5] and Stephen Smale [6].

The interest in *Chaos* started building up after a work accidentally carried out by Edward Lorenz in 1961 who was using a Royal McBee LGP-30 to run a weather simulation model [7]. When he re-entered the input data with three rounded digits (which was originally rounded to six digits), to his surprise the output weather was totally different from the first one. Such a negligible change in initial condition made drastic effect on the output of weather model indicating the sensitivity of chaotic models to initial conditions. Lorenz published a paper in 1972 entitled "Predictability: Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?" thereby emphasizing the importance of initial conditions. After that the sensitivity to initial conditions has popularly been referred to as "Butterfly effect". Lorenz discovery also proved that meteorology could not predict weather beyond a weekly period at the most.

Linear systems are never chaotic. For a dynamical system to display chaotic behavior it has to be non-linear. An interesting example of chaotic system is a fractal. A fractal is a geometrical shape produced by the iteration of a simple mathematical function or equation. A startling property of fractal is *self similarity* up to any scale of magnification [8]. Some popular fractals are Sierpinski triangle (Fig.1), Koch snowflake (Fig.2), Julia set (Fig.3), Cantor dust (Fig.4), Peano curve (Fig.5) etc.

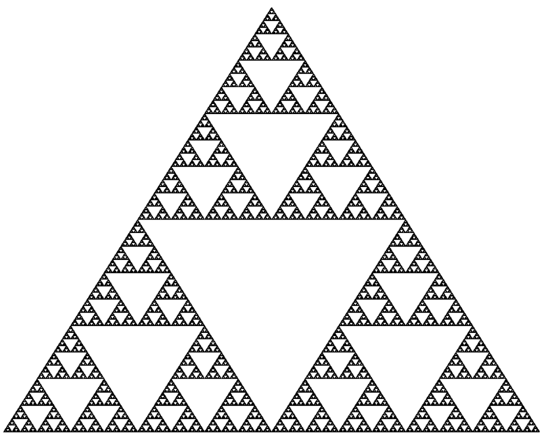

Fig.1 Sierpinski triangle: A fractal named after the Polish mathematician Wacław Sierpiński who described it in 1915.

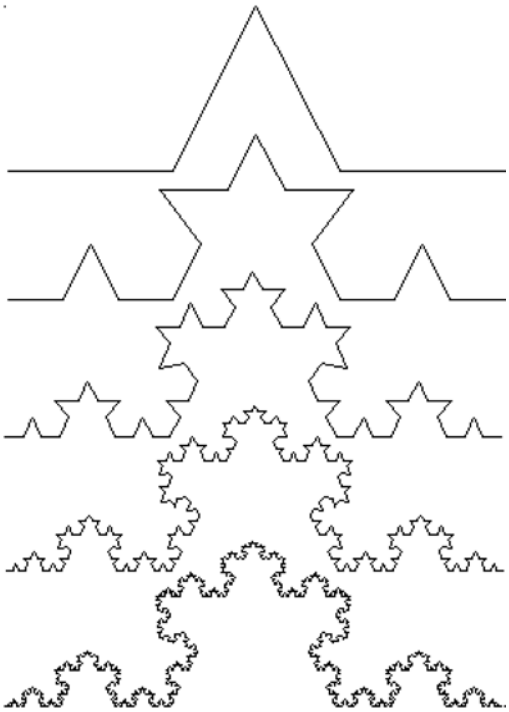

Fig.2 Koch snowflake: it is continuous everywhere but differentiable nowhere.

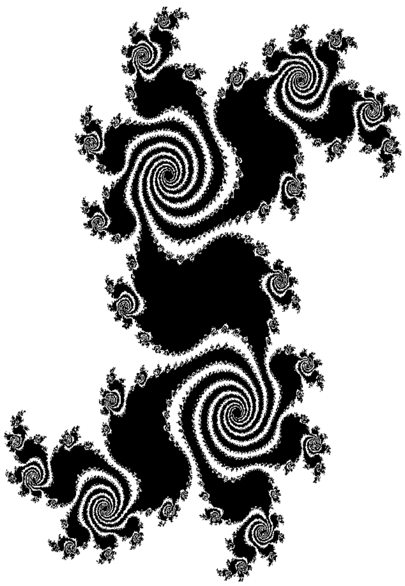

Fig.3 Julia set: generated from the iteration of $f(z) = z^2 + c$, where c is a complex parameter

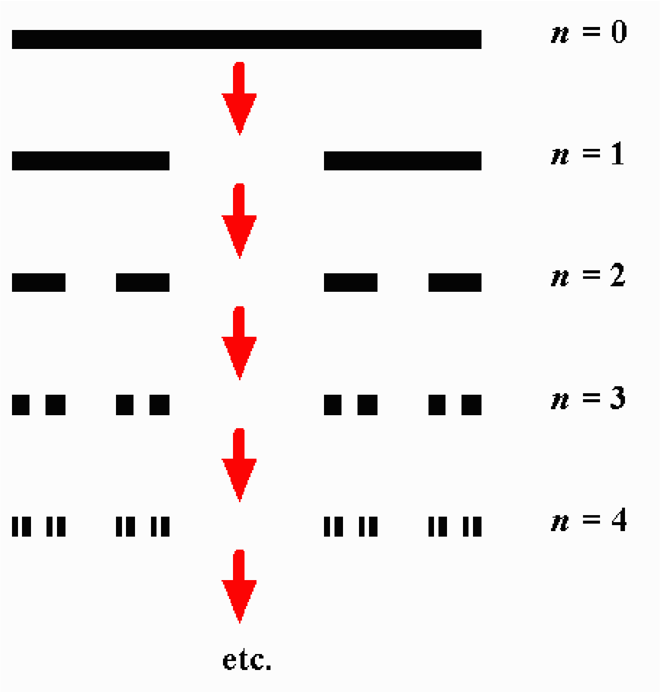

Fig.4 Cantor dust: built by removing the middle thirds of a line segment

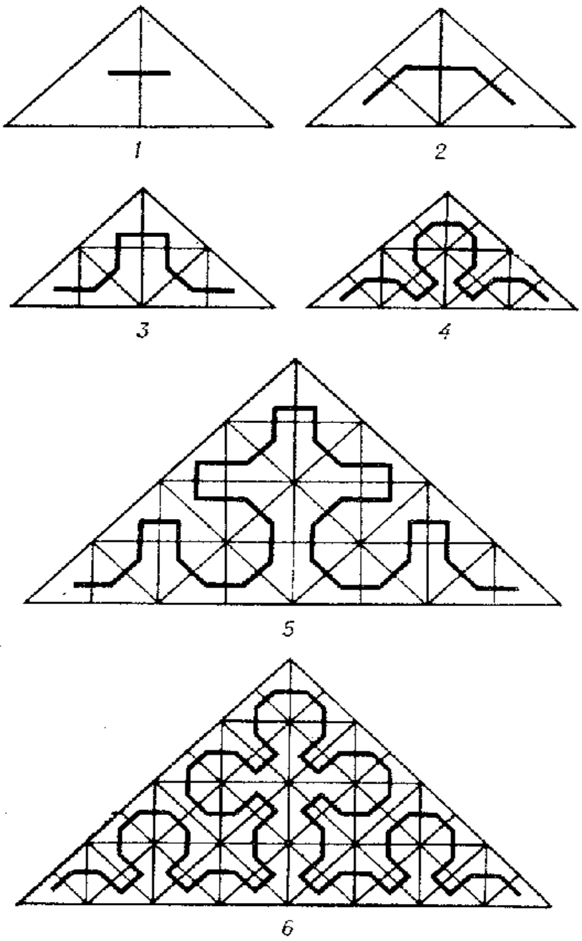

Fig.5 Peano curve: an example of a space filling curve, its range contains the entire two dimensional unit plane

It has also been observed that natural structures resemble fractals and can be regenerated quite easily by iterating very simple mathematical functions. Popular shapes include fern branch (Fig.6), Brownian motion (Fig.7), fractal landscapes (Fig.8), burning ship fractal (Fig.9), snow flakes (Fig.10), fractal blood vessels (Fig.11) etc.

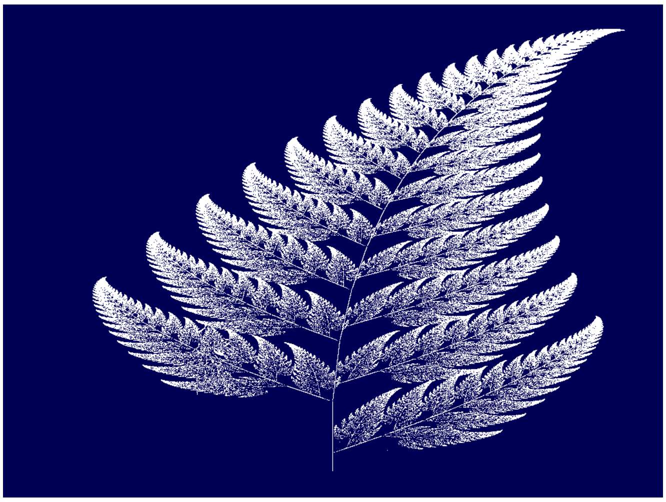

Fig.6 Fern branch: generated by using a fractal generating software like apophysics or chaospro etc.

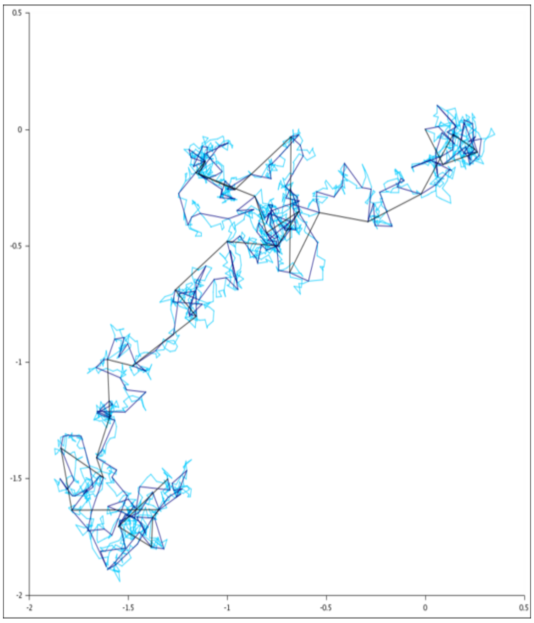

Fig.7: Brownian motion: A popular phenomena, has many real world applications e.g. stock market fluctuations

Fig.8: Fractal landscape: generated by using a fractal generating software like apophysics or chaospro etc.

Fig.9: Burning ship fractal: first described and created by Michael Michelitsch and Otto E. Rössler in 1992, it is generated by iterating the complex function $z_{n+1} = (|Re(z_n)| + i\,|Im(z_n)|)^2 + c$

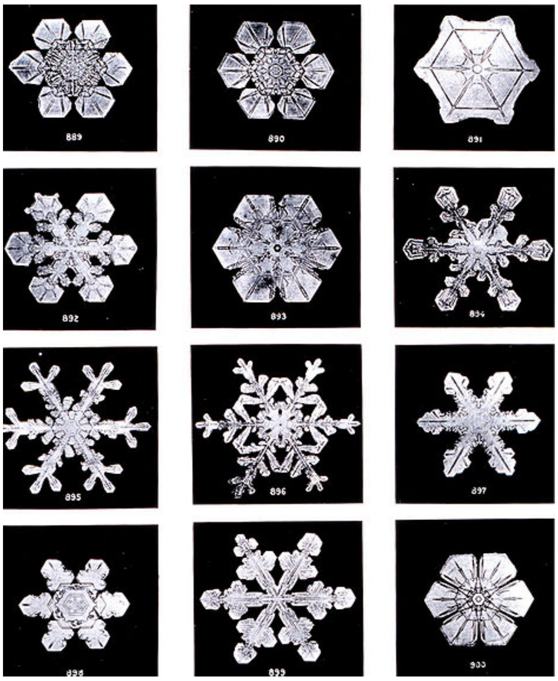

Fig.10 Snowflakes: a natural structure closely resembled by Koch snowflake

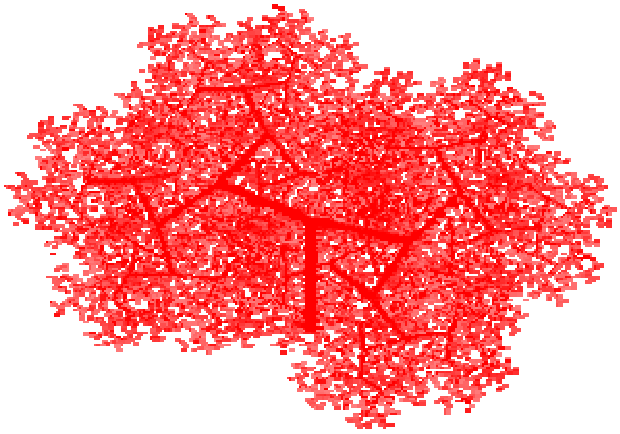

Fig.11 Blood vessels: another example of fractal occurring in nature.

Fig.12 the equation of Julia set is prominent in Google logo.

Chaos theory has been successfully applied in many scientific disciplines including mathematics, physics, biology, computer science, economics, population dynamics, ecology etc.

In the last have a look at the Google logo (Fig.12) which it published on its website on Feb 03, 2004 celebrating the birthday of Gaston Julia – a French mathematician – and discoverer of Julia set (Fig.3).

References:

1- Alligood, K. T. (1997). Chaos: an introduction to dynamical systems. Springer-Verlag New York, LLC. ISBN 0-387-94677-2.

2- Jules Henri Poincare (1890) "Sur le problème des trois corps et les équations de la dynamique. Divergence des séries de M. Lindstedt," Acta Mathematica, vol. 13, pages 1–270.

3- George D. Birkhoff, *Dynamical Systems,* vol. 9 of the American Mathematical Society Colloquium Publications (Providence, Rhode Island: American Mathematical Society, 1927)

4- Kolmogorov, A. N. (1941a). “Local structure of turbulence in an incompressible fluid for very large Reynolds numbers,” Doklady Akademii Nauk SSSR, vol. 30, no. 4, pages 301–305. Reprinted in: Proceedings of the Royal Society of London: Mathematical and Physical Sciences (Series A), vol. 434, pages 9–13 (1991).

5- Mary L. Cartwright and John E. Littlewood (1945) "On non-linear differential equations of the second order, I: The equation $y'' + k(1-y^2)y' + y = b\lambda k\cos(\lambda t + a)$, k large," Journal of the London Mathematical Society, vol. 20, pages 180–189.

6- Stephen Smale (January 1960) "Morse inequalities for a dynamical system," Bulletin of the American Mathematical Society, vol. 66, pages 43–49.

7- http:// en.wikipedia.org

8- Edward Lorenz, The essence of Chaos, University of Washington press 1996.

Photo Courtesy:

Fig.1:http://eldar.mathstat.uoguelph.ca/dashlock/ftax/Gallery/Siepinski1D960.gif

Fig.2:http://www.emeraldinsight.com/fig/0670340109062.png

Fig.3:http://eldar.mathstat.uoguelph.ca/dashlock/ftax/Gallery/Julia2D960.gif

Fig.4:http://www.math.lsa.umich.edu/mmss/coursesONLINE/chaos/chaos7/7.gif

Fig.5:http://eom.springer.de/common_img/p071890a.gif

Fig.6:http://www.mathworks.com/moler/ncm/fern png

Fig.7:http://en.wikipedia.org/wiki/File:Brownian_hierarchical.png

Fig.8:http://farm2.static.flickr.com/1058/555533669_d5c7b6147b.jpg?v=0

Fig.9:http://en.wikipedia.org/wiki/File:Burning_Ship_Fractal_Zoom.png

Fig.10:http://en.wikipedia.org/wiki/File:SnowflakesWilsonBentley.jpg

Fig.11: http://www.ioc.ee/res/pic/frpuu0.gif

Fig.12:http://www.google-logos.com/gaston-julias-birthday-2004.html

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New Research

Separation of single-walled carbon nanotubes (Metal/semiconductor) by DNA

Carbon nanotubes are relatively easy to grow, but it is very hard to separate them according to their electronic properties (Metal/semiconductor). Now Ming Zheng and colleagues at USA have devised a technique to separate a single-walled carbon nanotube (SWNTs) by chirality by mixing them with a solution of DNA and then using a standard chemical separation process known as liquid chromatography. The researchers believe that the technique will be very useful for nanoelectronics industry

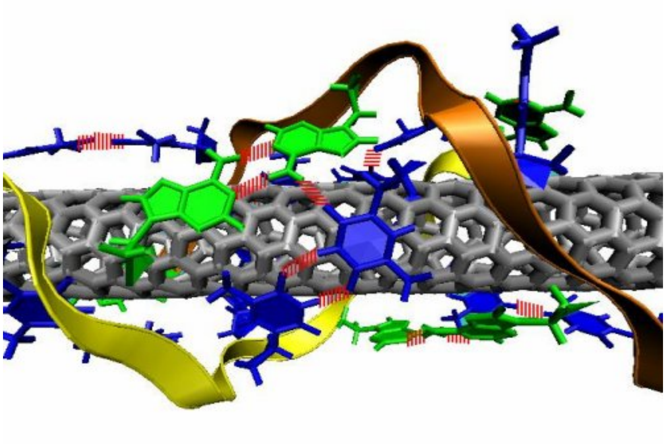

Fig.4: Short single stranded DNAs used by Tu et al. to purify single chirality carbon nanotubes from a synthetic mixture. Image shows a nanotube wrapped by two hydrogen bonded strands of DNA, with 12 purified tube structures as the background.

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Not wonder, this is Physics

When we are traveling in a jet plane, why do objects on the ground look as though they are still or moving slowly?

When we watch something moving, what we really notice is the change in the angle at which we see the object. A distant object heading towards or away from the viewer does not appear to be moving as quickly because the change in angle is very small.

When we watch a distant moving object, we do not see it changing angle quickly so we think it as moving relatively slowly. For example moon is moving at a speed of thousands miles an hour but we can not see it moving at all because we don't see the angular change in its position. Similarly when we look down from a high flying jet the distant ground is changing angles very slowly therefore it looks stationary or not moving fast.

News Bulletin

1. Dr. Ashsaq Ahmad, Associate Professor and Mr. Shahzada Qammer Hussian lecturer physics department participated in 34th International Nathiagali summer college on physics and contemporary needs: 2nd scientific activity on New and Novel materials for energy and environment from 29th June -4th July 2009
2. Dr. Hafiz Muhammad Ashfaq Ahmad, Assistant Professor and Dr. Muhammad Asif Assistant Professor physics department participated and presented their talks in First Science Conference: BICMAPE-2009 held at CIIT Abbottabad from 28th -29th July 2009
3. This year CIIT Lahore has announced admission in the MS leading to Ph.D physics program for semester fall 2009. The inception of graduate program is another hallmark for the physics department. All the best wishes for the MS physics program and many congratulations.
4. Dr. Javed Iqbal has joined the Physics Department as Professor on July 23, 2009. He is also the new HOD of the Physics Department. We wish him warm welcome and all the best wishes for his new assignment

Photo Gallery

Glimpses of the participation of Faculty in the national conferences are posted below.

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