

The Shape of Space: M-Branes and 11-Dimensional Geometry

Rafi Ullah Awan

Member Executive Committee

Khwarizmic Science Society

Study of the “shape of space” became very exciting with the advent of the famous theory of General Relativity put forward by Albert Einstein, the genius, in the 1910’s and is still a frontier of research in theoretical physics. The subject is very popular among the science community as well as in the general public because of its novel predictions like the existence of black holes, gravitational waves and higher dimensional geometries. All of these ideas incite young minds.

Considering the importance and popularity of the subject the Khwarizmic Science Society (KSS) organized a popular lecture titled “The Shape of Space: M-Branes and 11-Dimensional Geometry” held at Punjab University’s Physics Department on November 27, 2007.

The speaker was Dr. Tasneem Zehra Husain, an Assistant Professor of Physics at the School of Science and Engineering (SSE), LUMS, Lahore.

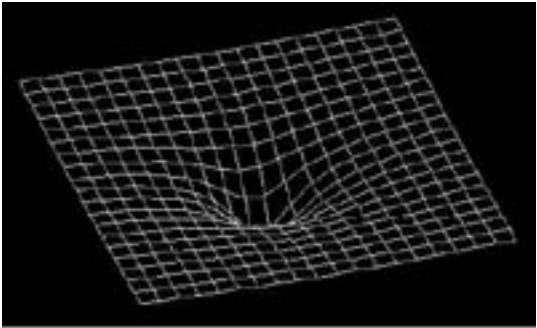
The lecture was organized by the KSS in collaboration with Punjab University’s Physics Department and special thanks to Tayyaba Zafar, Lecture at the same. Dr. Mujahid Kamran, Chairman of the Department of Physics presided over the session.

Dr. Tasneem’s lecture was ornamented with colourful slides, attractive animations and household examples and she made all possible efforts to present the topic in a highly comprehensible fashion. She stood to her reputation of making contemporary theoretical physics accessible to college students.

Dr. Tasneem started her lecture with a simple physical law that the shortest paths are always preferred, i.e., if a particle has to move from one point to the other it will prefer the path which can be traversed with minimum effort and this path can be called the “shortest path”. Furthermore, there are so many paths to move between two points but the shortest path is always unique. In flat (pseudo-Euclidean) space-time the shortest path between two points is a straight line. We can think of the flat space-time as flat sheet of rubber and until its flatness is not distorted the shortest path between two points is indeed

a straight line. Placing a heavy ball, such as a ball bearing, on the rubber sheet distorts its flatness, at least in the neighbourhood of the ball. In a similar way, the sheet of , space-time is also distorted by the presence of material objects. The distortion in space-time is proportional to the mass of the object, i.e., lighter objects cause less distortion while heavy objects cause more distortion. Black holes are the heaviest, and hence distort the sheet to the maximum.

A Schematic visualization of space-time



Curvature caused by a relatively lighter object



Curvature caused by a black hole

The curvature in space-time is sensed as a pull by nearby objects this pull we are familiar with and term it as the force of gravity. It's interesting to note that black holes are extremely heavy cosmological objects that cause an intense curvature in space-time, the resulting pull becomes so strong and nothing can escape from it, even light.

Whenever the space-time is distorted from the flat shape to some curved shape the shortest distance between two points is no more a straight line rather some complicated curve. Interestingly the shape of the curve, convey the geometry of space-time to which it belongs.

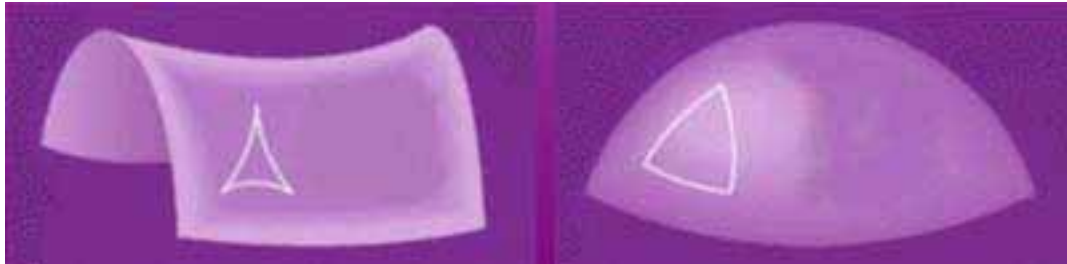
Triangle in flat sapce



A triangle in Euclidean space (sum of internal angles is 180°)

The curvature of space-time can also be visualized by another very simple example. It's a very famous theorem of elementary geometry that sum of the internal angles of a triangle is 180° . The theorem only holds for flat space and is no more valid in curved space and the sum may be greater than or less than 180° depending on the curvature of space.

Triangles in curved spaces



Sum of internal angles is less than 180° Sum of internal angles is greater than 180°

Dr Tasneem elucidated that mass is not the only property of matter rather the charge is another intrinsic attribute of matter. So if we take charge into account, the distortion of space-time is enhanced.

Going along with these simple ideas, the speaker introduced the mathematical concept of 'calibrations'. For the technically oriented, calibrations are differential forms that can be used to pick up the minimal surfaces in a given background. Cycles with minimal surfaces give the stable states as they have nothing to decay into or in other words, the states which are stable and supersymmetric are said to be calibrated. Calibrations, in other words, help us find minimal paths in arbitrary dimensions and their properties throw light on the underlying geometries.

At this point Dr. Tasneem sharply transitioned into the more mathematical aspects of her research, presenting her specialized work on M-Branes and 11-dimensional supergravity.

M-branes are charged, gravitating objects which modify the background into which they are placed. The back-reaction of an M-brane changes the background, by virtue of its mass and charge.

These M-branes, the speaker told us, live in higher dimensional spaces. The concept of higher dimensions is knotty to perceive and runs counter-intuitive to the usual concept of three dimensions of space and one of time. This conception is deeply rooted in our minds. But we can assume that the rest of the dimensions are curled up very tightly and they are so small that we are not aware of their existence. It is the mathematical consistency of String theory which makes us believe in these extra dimensions. but the downside is that String theory still awaits experimental substantiation.

The lecture was followed by a lively question and answer session. The lecture was attended by eminent scientists like Dr. Faheem Hussain, Dr. Tariq Abdullah, Dr Shaukat Ali and Dr Khalid Rashid along with the students from various departments of the Punjab University like Department of Mathematics, Space Science, Physics, Centre for High Energy Physics, Centre for Solid State Physics, College of Earth and Environmental Science and the Institute of Chemistry.

Finally Prof. Dr. Mujahid Kamran Chair of the session was invited to conclude the session. He remarked that even though there is no experimental evidence of String theory so far, but despite this experimental defiance, there is something beautiful and deep that so many intellectuals are actively involved in it. In the end, Dr. Mujahid presented a memento with a token of thanks to the guest speaker.

This lecture concluded another eventful year for the Khwarizmic Science Society. We look forward to an eventful and peaceful 2008.