Department of Mathematics Colloquium Series

DATE: Wednesday, October 7, 2009

PLACE: JR 202

TIME: 3:00 pm
(Refreshments will be served 15 minutes prior to the presentation)

SPEAKER: **Dr. Martin Lo**
JPL, Caltech

TITLE: *Applications of Topology to Science and Engineering Problems*

Abstract:

Topology has long been thought of as one of the most abstract (and useless for applications) of mathematical subjects. In the last decades, this has changed drastically due, to a great extent, to the increasing power of computers which now can handle complex algebraic topological computations. Two of the areas making the most dramatic advances are computer graphics and data analysis. From the more theoretical end, gauge theory and string theory in physics have embraced algebraic topology as one of their key tools. In this talk, I will address two applications of topological methods. The first problem is on the analysis of the large scale structure (LSS) of the universe form observational data. Here we simply wish to identify the various bubbles and filament structures from deep images of distant galaxies in the universe. While our eyes and brains can immediately pick out such structures, computing them on the computer is highly nontrivial. In this case, homology groups come to the rescue. A second problem is more theoretical, it addresses the problem of dark matter and dark energy. In the early 1990's, Carl Brans conjectured that dark energy is caused by the existence of exotic differential structures in spacetime. This is a topological phenomenon which exists only in dimension 4 and above so we have no intuition at all on what this means. It was first discovered by Milnor in 1954 that there are 28 distinct differential structures on the 7-sphere, for which he won the Fields Medal. The amazing fact is that of all dimensions, the differential structures of 4 manifolds stands uniquely alone. For example, all Euclidean spaces have a unique differential structure except in dimension 4 where R4 has an uncountable number of distinct differential structures. Another example: in all dimensions except 4 manifolds can have only a finite number of distinct differential structures. In dimension 4, so far all known exotic manifolds have infinite number of differential structures. Finally, the differential structures of spheres of all dimensions are known and classified except in dimension 4 where it is not known whether S4 has 1 or many distinct differential structure. This last is known as the "Smooth Poincare Conjecture in Dimension 4" and is one of the 23 DARPA Mathematical Grand Challenges.