Carnegie Mellon University
Department of Physics

McWilliams Center for Cosmology
Colloquium

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Tuesday, December 2, 2008
3:30 pm
DH A301D

"The key role of baryonic physics in cosmic structure formation: from galaxy formation to mergers of supermassive black holes"

Abstract:

I will discuss the status of supercomputer hydrodynamical simulations designed to model two fundamental processes of cosmological structure formation; the orbital decay of supermassive black holes (SMBHs) in merging galaxies, which leads to their eventual coalescence via gravitational wave emission, and the formation of galaxies in the cold dark matter model.

I will show that the physics of the interstellar medium and the process of star formation, namely mechanisms occurring at the level of baryonic matter, are fundamental to understand both processes even in a Universe dominated by cold dark matter. I will show how new, more realistic models of baryonic processes in state-of-the-art supercomputer simulations with unprecedented resolution appear to shed light on some of the key puzzles in the field. In particular, I will show how the long-standing problem of forming realistic disk galaxies resembling our own Milky Way can be solved within the currently favored LCDM cosmology thanks to a better description of baryonic physics. Therefore, contrary to the arguments of many, there is no need to put into question the underlying cosmology. Whether or not these new models can explain the wide variety of galaxies seen in the Universe, and not just galaxies similar to ours, is yet to be seen, but preliminary results are promising. I will then examine the first stage of SMBHs mergers, namely the formation of a binary of SMBHs, showing that it is likely governed by the dynamical and thermodynamical interaction with the surrounding interstellar gas. I will discuss the efficiency of the interaction with the surrounding interstellar gas. I will discuss the efficiency of the binary SMBHs formation process during the cosmological assembly of galaxies, posing the basis for a quantitative model aimed at interpreting the demographics of gravitational wave bursts that instruments such as the Laser Interferometer Space Antenna (LISA) should be able to detect during the next decade.