APCTP People:
An Introduction to the Biological and Soft Matter Theory Lab

Yong Seok Jho
JRG Leader in Biological and Soft Matter Theory, APCTP

June 1st 2011 marked the beginning of the Biological and Soft Matter Theory Lab, led by Yong Seok Jho. The long term goal of this group is to contribute to the understanding of the electro-static and dynamic properties of biological and soft systems, including charged polymers, colloids, and membranes. We particularly focus on their structure, instability, function, and dynamics. Both theory and simulations are applied to bridge the different length and time scales of phenomena. The research model spans from the simplified statistical model system to the real molecular biological system.

The three main research subjects we are concentrating on are as follows:

(1) The electrostatic properties of water

Water is ubiquitous in biological systems. The anomalous properties of water induce hydrophobic interaction and significantly reduce charge interaction between charged biomolecules dissolving into water. Due to these effects water shows especially anomalous behavior at various interfaces. We will study the origin of this anomaly in the interface and the bulk. Hierarchical simulation from a quantum mechanical scale to the coarse grained level is used to consider the anisotropy of water molecules and the long range correlations at the same time.

(2) Field theoretical and particle simulations on the charged biological system

The understanding of charged macromolecules, such as polyelectrolytes, is very challenging because it requires combining expertise in electrostatics, statistical mechanics, and macromolecular physics. In this field of study, we will develop numerical methods and theories which can be applied beyond the mean field regime.

(3) Charged polymers in neuron systems

Neurons are in charge of the transport of electrical and chemical signals in our body. Many compartments of neurons are charged and use charge interaction for their stability and functionality. Consequently, it is a very good area for us to apply our theoretical and numerical developments. Moreover, this area of study is not only important to the understanding of biological systems but also contributes to a broad spectrum of technological applications in medicine. We study the stability of microtubule complexes, neurofilaments, and signal transport at synapses and their malfunction (which leads to major neurological diseases), in collaboration with experimental and theoretical groups.

Our group is composed of one postdoctoral researcher (Dr. Adi Constantinescu), and two graduate students (SeongMin Jeong, YongJin Lee) from POSTECH. We are closely interacting with YST (Young Scientist Training) fellows at APCTP (the Asia Pacific Center for Theoretical Physics). Strong collaborations are being built with domestic experimental groups and international theoretical groups.

Astro-Particle Physics and Cosmology Group of APCTP

Ki Young Choi
JRG leader in Astro-Particle Physics and Cosmology, APCTP

At the Astro-Particle Physics and Cosmology Group of the Asia Pacific Center for Theoretical Physics (APCTP) we study the origin, evolution and future of the Universe. In July 2011, I, Dr. Ki Young Choi, became leader of this group. We presently employ Dr. Soo A Kim as a researcher, and we have plans to include new postdocs and students to our group in the future.

The ancient, intuitive understanding about the nature of the Universe became a physical science in 20th century due to help from a theory by Einstein and the development of science and technology. The recent measurement of the cosmic microwave background radiation and the distribution of distant galaxies using satellites precisely determine not only the amount of the components in the Universe but also the initial inhomogeneities in the energy density that existed in the early age of the Universe, much before the formation of the structures such as galaxies.

One of the current problems of modern cosmology is to reveal the origin of the matter components filling the Universe; at present it is 74% dark energy, 22% dark matter and only 4% atoms according to observations by the Wilkinson Microwave Anisotropy Probe (WMAP). Another is to understand the mechanism of the generation of the initial density perturbations in the energy densities of the early Universe that are amplified by the gravitational instabilities to become large scale structures at present. In order to seed the initial formation of structures, dark matter must have existed in the early Universe.

One of the aims of the group is to identify the evidence of dark matter and reveal its origin with observable signatures. Particle physics provides candidates for dark matter and there are well-motivated suggestions such as weakly interacting massive particles (WIMPs), gravitinos, axinos or axions, etc., which could explain the discrepancies between visible matter and gravitational matter. Dark matter can be detected either directly by observing the scattering off the targets in the underground experiments and/or indirectly from the anomalously energetic particles that come from the sky.

The existence of new particles beyond the standard model would modify the physical state of the early Universe and would change its evolution. We can use the early Universe as a laboratory to test new theories of particle physics complementary to the accelerators on the ground. The group is interested in identifying and constraining the theory beyond the standard model, using cosmological and astrophysical phenomena.

The other interest of the group is the inflation model in the early Universe and the generation of the primordial curvature perturbation. Cosmic inflation is a popular mechanism for the observed homogeneity and isotropy in the Universe. Furthermore the tiny perturbations in the small scales created due to the

Ki Young Choi received his PhD in particle physics from Seoul National University in 2005. From 2005 to 2009, he worked as a research associate at Sheffield University, United Kingdom and at Madrid Autonoma University, Spain. From 2009 to 2011, he was a research professor in Pusan National University, Korea. Since 2011, he has been a Junior Research Group (JRG) leader at APCTP. His research field is particle cosmology and astrophysics.

quantum fluctuations are stretched to the galactic scales during inflation period and become the seed for cosmic microwave background (CMB) anisotropy and large scale structure formation. The Planck satellite, which measures the most precise CMB temperature anisotropy, may reveal the non-Gaussian feature of the anisotropy in the near future. The group is working on the mechanism of generating large non-Gaussianity and specific inflationary models which can realize the mechanism. The multi-field inflation models such as N-flation and multi-hybrid inflation are interesting candidates and are being analyzed.

The Astro-Particle Physics and Cosmology Group of APCTP is newly established and we are planning to extend our fields of research and to hire new members.

Interested postdocs and students are welcome to contact:
Dr. Ki Young Choi (email: kiyoung.choi@apctp.org)

For more information, please visit:
http://apctp.org/jrg/ blogindex.php?JrgId=9