Research interests:

- Biological complex systems:

Biological systems are surely the prototypes of complex systems, so novel concepts and tools developed in the field of complex systems are the best to study biological phenomena. Accordingly, I have been highly involved in studying some biological complex systems, e.g. random walk of small and large molecules in the highly organized environment of cell surfaces and interiors, on protein and DNA surfaces, etc. I have mainly used the cellular automata models to study these phenomena: introducing controlled inhomogeneities into lattice, analyzing the anomalous diffusion of walker, searching for phase transition and percolation phenomena and analyzing the multifractal features of walk over the lattice. I think this approach can find some novel implications for properly structuring cell surfaces and interiors. Recently, I have started a collaboration to apply these concepts and computational methods to analyze DNA and protein sequences, a promising view to search for "linguistic properties" of biologic sequences.

-Biological networks:

Molecular biology is now progressively producing data on biological elements and interactions. It is fantastic, but without a system biology approach, it is hard to obtain a reasonable understanding about how this complex network of interactions works. The structure, dynamic and evolution of these complex networks need to be analyzed in both large and small scales. I am interested to study the large-scale topological features and dynamic behaviors of biological networks (intra-molecular networks, metabolic networks, signal transduction networks, immune networks, neuronal networks, etc.) in terms of network theory. As well, the frequent occurrence of some elementary circuit units (called as "network motifs") in complex biological networks (e.g. Feed-Forward Loops) make it possible to analyze the networks at a small-scale. I am interested to search for the design principles of "network motifs", by using concepts and methods, developed in the field of control theory.

- Protein-protein interaction, protein structure and dynamics:

In my PhD thesis, I am studying a specific type of protein-protein interaction: protein aggregation. This phenomenon is critically important in neurodegenerative (e.g. Alzheimer's and Parkinson's diseases) and some other diseases (e.g. some types of diabetes), as in some biotechnological processes. Briefly, I induce good-behaving aggregation in my protein via diverse physical and chemical tools, then try to characterize the induced aggregation-prone structure of protein through several biophysical methods, and develop suitable mathematical models to explain the observed kinetics of aggregation. I also try to rationally design methods to facilitate or inhibit the aggregation process. In all these, I also apply mathematical and computational techniques, e.g. numerical solution of mathematical kinetic models, Molecular Dynamic (MD) simulation to study protein structure and dynamics in some aggregation inducing conditions and cellular automata models to simulate the diffusion-limited aggregation of proteins.