Arman Shafieloo

Cosmology is at its golden age and it will be a growing field of science in the next decades considering the variety of surveys functioning at the moment and the long list of surveys funded and planned to observe the universe at different wavelengths, scales and depth in the near and far future. In the Physical Cosmology Group we work on advanced and innovative statistical methods of data analysis to robustly compare theory and observations. Our focus is predominantly on investigating important areas in astrophysics and cosmology from the nature of the primordial seeds of structure to the current cosmic acceleration. One of our main targets is in falsifying different aspects of the concordance model of cosmology known as the vanilla model (cosmological constant as dark energy, power-law form of the primordial spectrum, flat, homogenous and isotropic FLRW universe) through applying various statistical techniques on the most recent cosmological observations.

The activities of the Physical Cosmology Group have three main foci:

1. Late universe and dark energy,

2. CMB, the primordial power spectrum and early universe scenarios, and

3. Falsification of the standard model of cosmology

The following is a brief explanation these subjects:

1. LATE UNIVERSE AND DARK ENERGY

Our research activities related to dark energy and the late universe are mainly focused on reconstruction of the expansion history of the universe and the properties of dark energy where we try to understand the dynamics of the universe and study how it has evolved over time. We use different advanced statistical techniques including smoothing methods, genetic algorithms, Crossing statistics and Gaussian processes applied to different cosmological observations and in particular supernovae type Ia and large scale structure data to do the analysis and reconstruction. In our studies about the late universe we also work on different statistical methods to probe the unknown systematics in different cosmological observations. This is usually done by comparing different data in a novel, independent way. Dark energy modeling and supernovae light curve analysis are other subjects related to the late universe that we study at the Physical Cosmology Group.

2. CMB, PRIMORDIAL POWER SPECTRUM AND EARLY UNIVERSE SCENARIOS

Despite the strong theoretical appeal and simplicity of a featureless primordial spectrum, it is important to determine the shape of the primordial power spectrum directly from observations with minimal theoretical bias. In our group we implement and apply different algorithms, including the Richardson-Lucy deconvolution method of Cosmic Microwave Background (CMB) data to reconstruct and study the form of the primordial spectrum. The reconstructed form of the primordial spectrum can guide us toward some specific inflationary scenarios and this can be used to study the early universe. Cosmological parameter estimation, assuming the free form of the primordial spectrum; studying the expansion history of the universe using the Integrated Sachs-Wolfe (ISW) effect, confronting inflationary scenarios with the most recent CMB observations including the data from the Planck satellite are some of the other topics that we study in our group at APCTP.

3. FALSIFYING THE STANDARD MODEL OF COSMOLOGY

The standard model of cosmology, known as the 'Vanilla Model' because of its simplicity can be summarized as a spatially flat homogeneous and isotropic large scale Friedman-Lometre-Robertson-Walker (FLRW) universe with the power-law form of the primordial spectrum for the initial fluctuations and constitution of baryonic matter, cold dark matter and cosmological constans as dark energy. The standard model of cosmology is in fact based on many assumptions providing only 6 parameters to explain the universe and its dynamics. One should admit that despite the simplicity of the concordance model, most cosmological observations are in good agreement with this model and in fact there is no strong evidence against it with the current status of observations. However, the agreement of this model with most cosmological observations does not necessarily mean that we have found the actual model of the universe. Different assumptions from the standard model can be independently tested and falsified using different statistical methods applied to various cosmological data. In our group we try to falsify various assumptions of the standard model. These include: testing the isotropy and the homogeneity of the universe using low redshift supernovae type Ia (SN Ia) data and distribution of the galaxies, testing the structure formation suggested by the standard model using galaxy cluster counts, testing the flatness of the universe using large scale structure data, testing the power-law form of the primordial spectrum using CMB temperature and polarization data, and testing the cosmological constant as dark energy using SN Ia, baryon acoustic oscillation and CMB data. One should note that falsification of different aspects of the standard model has a particular importance since finding any significant deviation from it would result in a breakthrough in theoretical physics, ruling out the standard concordance model of cosmology.

Arman Shafieloo did his undergraduate studies in Sharif University of Technology in Tehran, Iran and left for India to do his PhD at the Inter-University Centre for Astronomy and Astrophysics (IUCAA) in Pune. After finishing his PhD in 2008 he moved to the University of Oxford as a Marie Curie fellow for two years and in 2010 he joined the Institute for the Early Universe (IEU) in Ewha W. University in Seoul as an IEU fellow. From October 2012 he joined APCTP as a junior research group leader (Physical Cosmology).