Title:	Reconstructing Cosmology using Principal Component Analysis
Authors:	Sharma, Ranbir
Keywords:	Reconstructing Cosmology Component Analysis
Issue Date:	Dec-2022
Publisher:	IISER Mohali
Abstract:	evolution of the Universe using different statistical methods. In the first part of the the- sis, we apply the Principal Component Analysis(PCA) to reconstruct the observables in Cosmological data-sets. PCA is a model independent, non-parametric method and can be used to separate the noise of the data from the signal. PCA is an application of linear algebra and we need only the tabulated data-set of the observational quan- tity as our input. As output we obtain the form of the observable which describes the data-set the best. We modify the PCA algorithm via the calculation of the Covariance matrix. We show that the combination of correlation coefficient calculation(CCC) and PCA (PCA + CCC) can be used as a potential reconstruction tool. (PCA + CCC) give a prescription of selecting the number of final principal components that are sufficient to reconstruct the final observable. We apply our algorithm on a simulated data-set first to validate and check the efficiency of our algorithm. We devise two approaches in the PCA mechanism. The first one is a derived approach, where we reconstruct the observable quantities using PCA and subsequently construct the equation of state pa- rameter of dark energy. The other approach is the direct reconstruction of the equation of state from the data in hand. We use different initial basis vectors to reconstruct the observable quantities and use CCC to select one particular initial basis vector over the other. Given the data-set, we use CCC also to select one approach over the other. The reconstruction of the equation of state indicates a slowly varying equation of state of dark energy. In the second part of the thesis, we combine PCA and Markov Chain Monte Carlo (MCMC) to infer the cosmological model parameters. We use the No U Turn Sampler (NUTS) to run the MCMC chains in the model parameter space. After validating our methodology with simulated data, we apply the same to observed data-sets. Here we take the points generated from the PCA reconstruction of the observable as the data-set for the Maximum Likelihood Estimation (MLE) and a specific cosmological model as our theory vector. We assume a polynomial expansion over the variable $(1 - a)$, where a is the scale factor as the parametrization of the equation of state of dark energy(EoS). When the method of (PCA + CCC) reconstruction is combined with MCMC tool, we have the freedom of selecting the number of points in the observational part of MLE. We see that the predictions for the model parameters are viable. We show that the pa- rameter estimation does not depend strongly on the prior probability assumption, and the idea can be generalized to other data-sets as well as different sampling techniques. The relation between the Hubble parameter and the equation of state of dark energy also contains the first differentiation of the Hubble parameter, which introduces an unwanted error in the equation of state predictions. This method eliminates the er- ror that arises from the first order differentiation of the Hubble parameter to infer the value and ranges of the Equation of State of dark energy. In this work, we only use the error function that comes directly from the PCA algorithm, and one can use different error functions in the error part of the MLE as well. It can be used as a model selection tool and can be used in those data-sets which have fewer data-points.
URI:	http://hdl.handle.net/123456789/5335
Appears in Collections:	PhD-2015

Files in This Item:

File	Description	Size	Format	
thesis.pdf		13.29 MB	Adobe PDF	View/Open