Caspen Program Report

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Host: Andreu Font-Ribera, University College London
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Purpose of visit

I visited UCL to initiate a collaboration with Andreu Font-Ribera and his doctoral student, James Farr, on aspects related to simulation of the Lyα forest. In the published work of Tie et al. (2019), I modeled the three-point correlation function (3PCF) of the Lyα forest using numerical N-body simulation and provided a rough estimate of the expected 3PCF signal for the future Dark Energy Spectroscopic Instrument (DESI) survey. However, the signal estimate does not include realistic observational and instrumental noise from the actual survey. Andreu Font-Ribera and James Farr are heavily involved in simulating the Lyα forest and have produced mock spectra of the Lyα forest for DESI, dubbed the London mocks. As such, the purpose of this visit is to learn about the London mocks and the related simulation tools such that I will be able to use the mocks for estimating DESI sensitivity in detecting the 3PCF of the forest.

Work and activities during visit

During the week at UCL, with Andreu's and James' help, I processed a small subset of London mocks through the DESI *quickquasar* pipeline, which acts to add instrumental noise and other astrophysical effects to the noiseless London mocks. I then learned to use the DESI Lyα forest correlation function calculation package, `PICCA`, to create the flux fluctuation field from the processed spectra. The spectra of the flux fluctuation are what will be used for calculating the 3PCF. Figure 1 shows an input London mock spectrum of the Lyα forest (middle panel) compared with the output of *quickquasar* (left panel) and `PICCA` processing (right panel).

Currently, the London mocks do not have the correct value of the 3PCF. We therefore discussed the possibility of adding the correct 3PCF signal into the London mocks. We determined that it is possible to incorporate this effect as tools already exist for this purpose. As such, I also learned how to use two extra packages required for this modification of the London mocks: the `COLORE` package for creating the initial density field and the `LyaCOLORE` package, developed by James, to transform the initial density field into Lyα forest flux field.

Besides attending the weekly seminar and colloquium, I also participated in the 2-day DESI-UK meeting held at UCL, during which I gave a spotlight talk highlighting my ongoing work and the UCL collaboration.

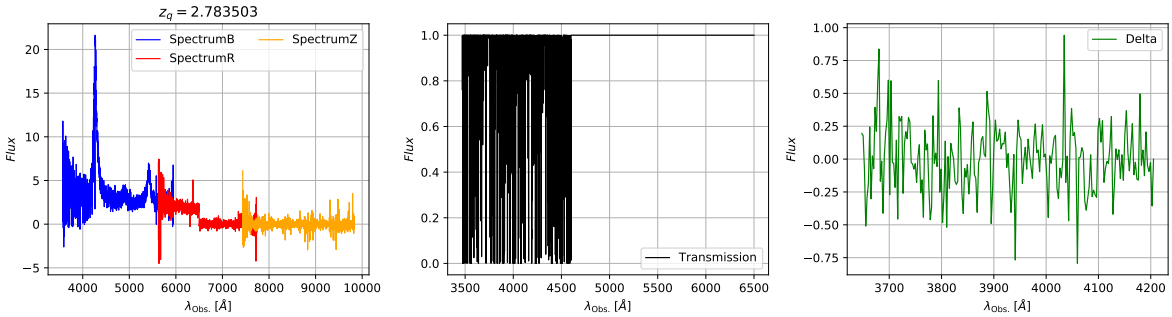

Figure 1: Progression of an initial raw spectrum of the Lyα forest into the final spectrum used for clustering analyses using DESI's *quickquasar* and `PICCA` pipelines. *Left panel: Quickquasar* output of the London mock spectrum, in which the background quasar spectrum is additionally imprinted on top of the raw Lyα forest spectrum. *Middle panel:* The input raw Lyα forest spectrum from the London mocks suite. *Right panel:* The final spectrum of flux fluctuation from `PICCA`'s processing of the *quickquasar* output. This is the final format of the spectrum used for clustering analyses of the Lyα forest.

Future work

The expected long term goal will be to produce a paper that will forecast DESI sensitivity in measuring the 3PCF of the Lya forest. Towards this end, I have learned the necessary simulations and tools during my visit. Future work remains to process several realizations of the London mocks through the *quickquasar* and `PICCA` pipeline in production mode using DESI computing facilities at NERSC.

In regards to including the correct 3PCF in the London mocks, the next steps include to run the `COLORE` code with its 2nd-order Lagrangian perturbation theory capability to create the initial density field and then to do various checks to ensure we still retain the correct two-point clustering measurement of the Lyα forest. After we have passed these consistency checks, we will process the `COLORE` output through James' `LyaCOLORE` package to produce the final flux field.

With help from Andreu and James, I expect to undertake these works for my remaining time at OSU and hopefully thereafter as well.

Acknowledgement

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