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Visiting Shirley Ho

CASPEN Exit Report

Visit Dates : 9 -24th November

### **Graph Convolutional Networks and Redshift Space Distortions**

I visited CCA to start a collaboration on a recently developed Machine Learning field, Graph Networks (GNs), and its implementations in cosmology. We found that predicting peculiar motion of galaxies could be a very promising application of these algorithms.

While Convolutional Networks treat the observed galaxy distribution as a 3D image, GNs take a graph as an input in which the different galaxies are represented as nodes. Due to the distribution of voids in the Universe, the graph representation is more efficient. It is also a more convenient representation from which we might be able to both extract and impose physical insights.

Although originally we planned on using these algorithms to analyze the stellar content of galaxies in the Illustris-TNG simulations, we realised that the galaxy's velocities can be a better testing ground due to their environmental dependence. In particular, we want to use these algorithms to reconstruct the real space positions of galaxies. 3-D galaxy maps of the Universe contain the angular position of galaxies on the sky, together with their redshifts. If the galaxies were at rest, as the photons they emit travel towards us through an expanding Universe, their wavelengths stretch accordingly. Therefore, we observe the redshifted light of distant galaxies. We can translate this redshift into a comoving distance using the Hubble factor,  $H(z)$ . However,

galaxies also move due to the gravitational pull generated by structures around them. If a source that emits light moves, its wavelength gets further redshifted due to the Doppler effect. If we ignored it, we would infer the wrong distance,  $s$ . We have devised a plan to implement a Graph Network that maps the redshift space position of galaxies into real space.

During my visit to CCA, I also had the opportunity to participate in regular meetings of the Cosmology group. Specially, I found the Machine Learning related meetings very useful, and the discussions were both educational and exciting. I also had the opportunity to share my current work by giving a talk at one of these meetings.

In summary, the outcomes of my visit were very positive to start a new collaboration in areas of interest for both the ICC and CAA. I would like to thank both the CASPEN program for funding the visit, and Shirley Ho for hosting me.