CASPEN exit report

Visitor: **Dr. Alessio Spurio Mancini**, University College London
Host: **Dr. Colin Hill**, Center for Computational Astrophysics (CCA)
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My CASPEN-funded visit at CCA was incredibly productive and enjoyable. I would like to express my sincerest gratitude to the people responsible for this amazing exchange programme, as I truly believe it is a wonderful initiative.

In particular, I would like to thank my host Dr. Colin Hill, who has been incredibly kind and proactive in ensuring a pleasant visit for me, and helped me present my research in multiple talks at the CCA as well as at Columbia University.

Colin and I worked on the implementation of COSMOPOWER (Spurio Mancini et al. 2022), my neural network emulator for CMB and matter power spectra, within the cosmological sampler COBAYA. The idea is to provide even easier access to power spectra computed by COSMOPOWER within a COBAYA likelihood, producing a wrapper between the two codes.

The immediate use case for this software implementation is the analysis of new, upcoming data from the ACT collaboration. Before reaching CCA, I spent two weeks at Princeton, visiting Prof. Jo Dunkley with funding received from the Alan Turing Institute Postdoctoral Enrichment Award. During this visit, Jo and I started discussing how to use COSMOPOWER for the next ACT data release, and with Colin at CCA we continued this work within the sampler COBAYA. A publication presenting this implementation should appear soon, and the upcoming publications from ACT will also feature heavy use of COSMOPOWER.

In addition, working with Colin and Dr. Boris Bolliet at CCA I started developing a new emulator for a beyond-LCDM model, Early Dark Energy (EDE, see e.g. Hill et al. 2021 for constraints on this model from ACT data). The theoretical predictions of power spectra in this model are even more expensive than in LCDM. Furthermore, as one turns on high-accuracy settings in the Boltzmann codes for this model, these increase the runtimes even further. Therefore, developing an emulator of EDE predictions would be of immense usefulness in view of applications to new constraints from ACT data. A student at Princeton has already produced an emulator for low-accuracy settings in their final thesis; with Colin and Boris, we started organising the non-trivial computational resources required to compute the training set for the high-accuracy emulator. A publication on this project will appear by the end of the year.

Furthermore, we discussed how COSMOPOWER can be used for other purposes, namely the emulation of computationally heavy predictions for Sunyaev-Zeldovich (SZ) cosmology. I also presented COSMOPOWER at the SZ workshop organised by Colin at CCA during the last days of my stay. There I was able to advertise COSMOPOWER even further to the SZ community; it was awesome to see it receive great interest from multiple research groups. Finally, it was a real pleasure to discuss COSMOPOWER and more generally Machine Learning - based approaches to cosmological inference with experts such as Prof. Spergel, Prof. Ho, Dr. Villaescusa-Navarro, Dr. Foreman-Mackey -- from whom I received many useful inputs, that I will treasure in my future research.

Overall, I could not be more enthusiastic and grateful about my CASPEN-funded stay at CCA, and I wholeheartedly encourage other students and postdocs to take advantage of this initiative.