Research Report
ICRR Inter-University Research Program 2021

Research Subject: Investigating the origin of the diffuse cosmic gamma-ray background in the CTA era

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Summary of Research Results:

During the cosmic 'high noon' (at redshifts of z~2-3), physical conditions and processes in galaxies differ dramatically from those in the local Universe. In particular, cosmic ray (CR) interactions, their associated production of particles and radiation, and their deposition of momentum play an essential role in shaping the evolution of galaxies (Owen et al. 2018, 2019b) as well as producing energetic cosmic backgrounds -- including a component of the extra-galactic gamma-ray background, EGB (e.g. Lamastra et al. 2017). Understanding the activities and interactions of CRs in young star-forming galaxies (SFGs) is important to uncover the details of feedback processes influencing their evolution, and spatial analyses of near-future EGB surveys will soon offer an important new opportunity to do this: the continued operation of the *Fermi*-LAT space telescope will reach exposure times sufficient to provide suitable data in the next three years (Owen et al. 2020b), and this will be complemented by the Key Science Projects (KSPs) of the upcoming Cherenkov Telescope Array, CTA (see *Science with the Cherenkov Telescope Array*, CTA Consortium 2017, in particular, KSP 8: Extragalactic Survey)

The three primary objectives of this project are:

(1) Develop realistic models of SFG redshift distributions throughout the cosmic noon, informed by cutting-edge observations of SFG populations and sub-populations;
Achievement: Initial work has been completed to construct tentative source sub-population models, informed by public results from large-scale numerical simulations (EAGLE and IllustrisTNG).

(2) Model the detailed signatures that SFG populations and sub-populations would leave in the EGB;
Achievement: A baseline methodology and computational code have successfully been developed, tested, and applied to example applications. This has been published with demonstration results in Owen et al. 2021.

(3) Assess the degree to which different redshift distributions of source populations could be resolved from EGB observations using up-to-date CTA instrument specifications, and develop preliminary analysis pipelines to demonstrate how such signatures could be extracted from realistic, simulated mock data.
Achievement: Theoretical modeling work to investigate possible signatures for different galaxy sub-populations has been completed and published in Owen et al. 2022.

Especially for objective (3), I planned to stay at ICRR for several months to understand the detail of the CTA instrument specifications and performances with guidance from experts. Unfortunately, due to the pandemic, I was not able to visit. This topic shall be continued and upgraded at ICRR with experts in the next few years.

No.