Topic for Master 2 Internship
Academic Year 2025-2026

TITLE : Correlating Extragalactic Background Light with CMB Lensing

Scientific Description

Galaxies and diffuse stellar components light up the sky across cosmic time. This integrated extragalactic glow across ultraviolet to infrared wavelengths is the extragalactic background light (EBL). In the near-infrared (NIR) wavelengths (0.75–5 μm), the EBL integrates stellar and nebular emission from all galaxies, along with diffuse intra-halo light (IHL). Its spatial fluctuations not only trace the web of large-scale structure (LSS), but also carry astrophysical information about the history of stellar emissivity and the galaxy-halo connection. Meanwhile, gravitational lensing of the cosmic microwave background (CMB) provides a projected map of the total matter—the convergence field, κ that peaks around redshift of $z\sim2$, the same era that contributes strongly to the NIR-EBL. Cross-correlating EBL maps with CMB lensing not only links light to mass with high signal-to-noise, it also tells us where the light comes from in the cosmic web—i.e., the typical halos hosting the emission—and helps separate galaxy light from more diffuse intra-halo light (IHL).

Recent works have shown that cross-correlating the far-infrared cosmic infrared background (CIB) with CMB lensing yields very strong detections and cleanly links dusty star-forming galaxies to the underlying matter field. In parallel, the line-intensity mapping (LIM) × CMB-lensing cross—previously thought to be highly suppressed after foreground cleaning—has been revisited: when line-of-sight correlations (from light-cone evolution) are retained in the theory, the signal is expected to be detectable at high significance. By contrast, the full NIR-EBL × CMB-lensing cross-correlation—treating the EBL as continuum plus emission lines—has not been explored. With NASA's SPHEREx mission soon to deliver all-sky EBL maps across 0.75–5 μm and high-precision CMB-lensing maps already public (Planck/ACT, with more coming), this study is both new and extremely timely.

Project Description

This Master's internship aims at delivering the first simulation-based proof of concept for NIR-EBL × CMB-lensing with SPHEREx-like data. Using existing maps and code as a starting point, and in close collaboration with the project supervisor and a postdoctoral researcher in the group, Zucheng Gao, you will assemble realistic test cases (deep and wide configurations), measure the cross-correlation, and confront it with a compact baseline model that separates broad continuum emission from line-dominated contributions while retaining the essential line-of-sight correlations. The goal is to establish the detection significance, identify the wavelength bands, angular scales, and sky areas that carry the most information, and obtain constraints on an effective emissivity–bias parameter (how strongly the EBL traces mass), the line-versus-continuum fraction, and a first constraint on any IHL-like contribution. This project naturally leads to a PhD thesis that takes the analysis to the next level by applying it to data, incorporating relevant observational systematics, improving the signal model, and extending beyond two-point cross-correlations.

Student Profile

We seek a highly motivated Master's student who is enthusiastic about research and comfortable with coding. Strong programming skills in Python and familiarity with numerical techniques are desired. Prior coursework in

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general relativity, cosmology, and scientific computing is ideal preparation for this project. Knowledge of cosmological probes—especially CMB lensing and clustering of biased LSS tracers—and experience modeling angular statistics are a plus but not required. Exposure to cosmological simulations is also beneficial. Good software practices (version control with git, clean, modular code, reproducible notebooks) together with a learning mindset and consistent, careful work will help you ramp up quickly.

Environment

The internship will take place within the Astroparticles and Cosmology team at LAPTh, which includes several permanent researchers, postdoctoral researchers, and PhD students. As an integral part of the internship, the student will participate in weekly group meetings and lab-wide seminars and journal clubs, which offer ample opportunities for scientific exposure and immersion in the day-to-day life of a theoretical physics lab.

Possible Extension as a PhD: Yes

Keywords: cosmology and astrophysics, cosmological surveys, cross-correlations, analytic modeling, simulations

Supervisor:

Name	*First name*	*Tel*	*Mail*	*Team*
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Applicants should contact the supervisor by mail.