Multi-Probe Inference and Derived Parameter Development in `Kosmulator`

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While the `Kosmulator` framework has already demonstrated its core multiprobe capabilities, the next stage of its development is essential for addressing modern cosmological tensions with high-resolution data. This Master's project aims to help elevate the framework to a global joint-likelihood standard by significantly expanding its observational library and implementing a critical architectural upgrade: an integrated engine for derived parameters.

The research will focus on the technical integration of diverse datasets, ranging from ground-based CMB observations to large-scale spectroscopic surveys. By developing a vectorised derived parameter module, the student will enable the framework to automatically calculate and store physically essential quantities like H_0 and S_8, allowing for a rigorous, real-time investigation of the discrepancies between early and late-universe probes within a unified inference environment.

Key Objectives

- **Derived Parameter Engine:** Implement a vectorised module to automatically calculate secondary quantities (e.g., S_8, age) from primary MCMC samples during the sampling process.
- **High-Multipole CMB Expansion:** Integrate likelihood modules for the Atacama Cosmology Telescope (ACT DR6) and South Pole Telescope (SPT-3G) to capture small-scale temperature and polarization data.
- **LSS and Spectroscopic Integration:** Incorporate measurements from the Baryon Oscillation Spectroscopic Survey (BOSS DR12) to provide robust constraints on expansion history.
- **Weak Lensing and Cosmic Shear:** Integrate data from the Kilo-Degree Survey (KiDS-1000) or Dark Energy Survey (*DES*) to address matter clustering amplitude tensions.
- **Tension Diagnostics:** Use the expanded observation suite and derived parameter engine to perform a comprehensive statistical comparison of standard and extended models using the standard AIC, BIC, and the extendent AICc and WAIC criteria.

Special Requirements

Candidates should have strong proficiency in `Python`. Experience with Boltzmann solvers and an interest in expanding high-performance, vectorised software for the international cosmology community are highly desirable.

This is a Master's level project serving as a direct architectural and observational expansion of the Honours-level `Kosmulator` statistics track.

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