Contribution ID: **13** Type: **not specified**

The ESPRESSO Redshift Drift Experiment – High-fidelity spectra of the Lyman forest of QSO J052915.80-435152.0

Monday 14 April 2025 15:15 (15 minutes)

The elusive cosmological redshift drift —predicted by General Relativity as a direct signature of the universe's accelerated expansion —remains one of the most ambitious goals in observational cosmology. In this study, we take the first steps toward detecting this effect using the Lyman-α forest of bright quasars as tracers of the expanding cosmos. Focusing on the brightest quasar, J052915.80-435152.0, we present results from two high-resolution, high signal-to-noise (SNR) spectral epochs observed with ESO's ESPRESSO instrument. These observations serve as the initial benchmarks for a decades-long experiment to monitor the redshift drift.

By comparing the two epochs through a model-based approach, we assess the precision of velocity measurements achievable at the current SNR, providing a reality check on theoretical expectations. Our analysis reveals a null drift in the Lyman-α forest, with a measured velocity shift of $\Delta v = -0.32 \pm 4.55\ \mathrm{m\,s^{-1}}$ over a timespan of 0.8 years. This corresponds to a cosmological drift rate of $\dot{v} = -0.36 \pm 5.31\ \mathrm{m\,s^{-1}\,yr^{-1}}$, or a redshift drift of $\dot{z} = (-0.55 \pm 7.5) \times 10^{-8}\ \mathrm{m\,s^{-1}\,yr^{-1}}$, where the expected signal in a ΛCDM cosmology is $\dot{v} = -0.47\ \mathrm{cm\,s^{-1}\,yr^{-1}}$, clearly undetectable at the current stage. The achieved precision is slightly below expectations, highlighting key challenges in achieving ultimate sensitivity.

Extrapolating from these results, we estimate that detecting the cosmic redshift drift at 99% significance will require a long-term campaign of 5000 observational hours over 50 years using an ELT/ANDES-class spectrograph. This work marks a critical first step in a generational experiment to measure one of the most profound indicators of our universe's evolution.

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Session Classification: Session 3 - Modified Gravity & Dark Energy

Track Classification: Talk