STUDYING THE UNIVERSE'S FIRST STARS WITH LUNAR RADIO TELESCOPES

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Introduction: The era in which the Universe's first stars formed, likely about 50 million years after the Big Bang, is one of the frontiers of observational cosmology. Unfortunately, these sources formed in tiny clumps that are too faint to be observed individually. But the radiation backgrounds generated by such sources have dramatic effects on the neutral hydrogen that pervades the Universe at these early times. This sea of hydrogen can be observed, at least in principle, through its "spin-flip" transition, which produced photons with a rest wavelength of 21 cm. Thanks to the cosmological expansion, such photons can be observed at low radio frequencies (<200 MHz). Such observations are extremely challenging, both because of bright astrophysical foregrounds and because of terrestrial effects, such as manmade signals and the ionosphere. The far side lunar environment offers an ideal platform to make these measurements while avoiding terrestrial interference and ionospheric absorption.

Project Summary: Here, we demonstrate how the first generations of stars affect the 21-cm signal. We present a new semi-analytic model parameterizing the unknown physics of these sources, and we examine its implications for both the sky-averaged 21-cm background and fluctuations in that background across the sky. We show that these stars substantially affect the timing of the signal for a wide range of models, especially at the relatively low frequencies for which lunar measurements will be well-suited, and we show how measurements can reveal characteristics of the first generations of stars and black holes as well as the transition from these exotic objects to "normal" galaxies. We also describe the implications of these models for optimizing lunar telescopes.