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An SKA-Low RM Grid for constraining the origin of cosmic magnetism

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Abstract

Understanding the origin and evolution of cosmic magnetic fields is a key science goal for the SKAO. Recent advances in metre-wavelength ($m\text{-}\lambda$) Faraday rotation measure (RM) grids are enabling precision probes of cosmic magnetism, with implications extending to early-Universe physics, AGN feedback, and the magnetized circumgalactic medium. Here we model the $m\text{-}\lambda$ polarized source counts to predict an RM Grid density with SKA-Low of $N(>P) \sim 5(P/100\mu\text{Jy})^{-0.75} \text{deg}^{-2}$, where P is the polarized intensity detection threshold. This represents at least an order of magnitude improvement over the current state-of-the-art. For a representative wide-area SKA-Low AA4 survey covering $10,000 \text{ deg}^2$ in $\sim 3,200$ hours, we predict more than 50,000 RMs. Coupled with an expected RM precision of $\sim 0.05 \text{ rad/m}^2$, SKA-Low promises to produce the leading RM Grid survey for constraining the origin of cosmic magnetism in the SKA era. These predictions can be partially tested during the Science Verification phase using the AA* Sky Model data. For example, at a nominal detection threshold of $240 \sim \mu\text{Jy/beam}$ (8 times the noise in Stokes Q and U), we expect $\sim 2.6 \text{ RMs/deg}^2$ (5x the current best $m\text{-}\lambda$ RM Grid density). Combining both wide-area and all-sky data, SKA-Low could detect up to 100,000 $m\text{-}\lambda$ RMs across its observable sky. Finally, we demonstrate new constraints on the origin of cosmic magnetism by comparing cosmological MHD simulations with the LOFAR $m\text{-}\lambda$ RMs, and highlight the transformative advances an SKA-Low RM Grid will enable for precision studies of cosmic magnetism.



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