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Rethinking Recombination Primordial magnetic fields, small-scale inhomogeneities, and their implications for the Hubble tension

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One of the ways to resolve the Hubble tension is to modify the recombination history of the universe. An intriguing proposal to realize this invokes primordial magnetic fields (PMFs) to stir up the plasma on small scales. A clumpy baryon density field recombines faster than a homogenous one, which would push the surface of last scattering to earlier times and increase the inferred distance to it, as well as the value of the Hubble constant H0. Previous work on this mechanism has treated the recombination problem in a simplified manner, by taking the fluctuations induced by PMFs for granted and modifying existing codes that solve recombination in a homogenous universe in an ad-hoc manner to estimate the average recombination rate. In reality, recombination involves photons in the Lyman-alpha resonance and the Lyman-continuum. On the small scales at which PMFs introduce baryon clumping, the nonlocal transport of these photons becomes important. Our preliminary results utilizing a linearized framework which accounts for the non-local radiative transport indicate that PMFs are not effective in sourcing significant growth rates in the baryon density field across many length scales. Furthermore, on the smallest scales, modified silk and neutrino diffusion damping in the presence of PMFs inhibit the seeding and growth of inhomogeneities. Our studies are ongoing to determine whether there is still a range of length scales for which PMFs that respect PLANCK18 constraints can source inhomogeneities. We plan to present results demonstrating that a naive treatment of recombination in an inhomogeneous plasma with PMFs can reproduce substantial clumping across many length scales. However, when the full radiative transport is accounted for, it suppresses growth across a wide range of scales. We will also present our continuing work in determining the diffusion damping scale in the presence of PMFs. Not only is this the first work to date that provides a detailed treatment of the evolution of PMF-induced small scale inhomogeneities, but the general framework we have developed is useful for any future proposals to modify the recombination history on small scales.

Presenter: Dr SCHIFF, Jonathan (University of California Santa Barbara)