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## Chemical-Potential-Assisted Particle Production in FRW Spacetimes; Uncalibrated cosmic standards (UCS) and Early-Universe-Physics Insensitive determinations of the Hubble Constant

*Tuesday, September 21, 2021 3:00 PM (2 hours)*

We analyze gravitational particle production assisted by chemical potential. By utilizing the uniformly smoothed Stokes-line method and Borel summation, we gain insight into the fine-grained history of enhanced particle production. Analytic/semi-analytic formulae describing the production amount, time and width are obtained for both spin-1 and spin-1/2 particles in various FRW spacetimes. Our work also serves as a concrete demonstration of the uniformly smoothed Stokes-line method applied to cosmology.

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To further investigate whether pre-recombination physics alone can resolve the Hubble tension, we explore  $H_0$  determinations that are insensitive to early-universe physics. The similarity between the two sound horizons at recombination and at the drag epoch is insensitive to early-universe physics. This allows us to relate the two horizons and treat them as free parameters. Together with Type Ia supernovae, these uncalibrated cosmic standards (UCS) robustly constrain the matter density fraction. Combining with other non-local observations, we obtain several constraints on  $H_0$  with significantly reduced sensitivity to early-universe physics, which are consistent with Planck. These results suggest that pre-recombination physics cannot fully resolve the Hubble tension.

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