



Rayleigh Scattering of the CMB

Motivation and Opportunities

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(On behalf of the CCAT-prime Rayleigh Scattering Working Group)

CCAT-prime Collaboration Meeting

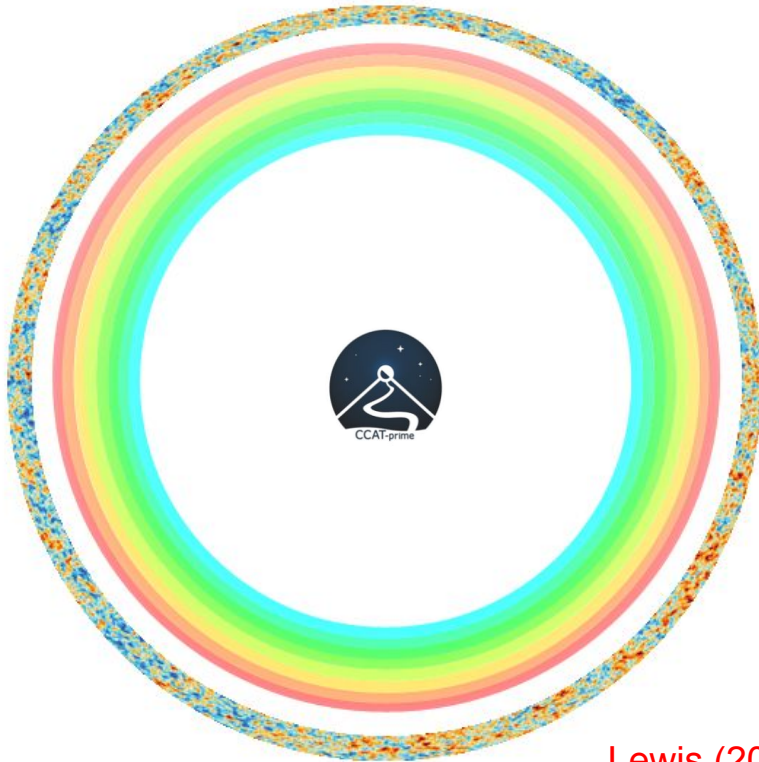
April 8, 2020

Thomson Last Scattering



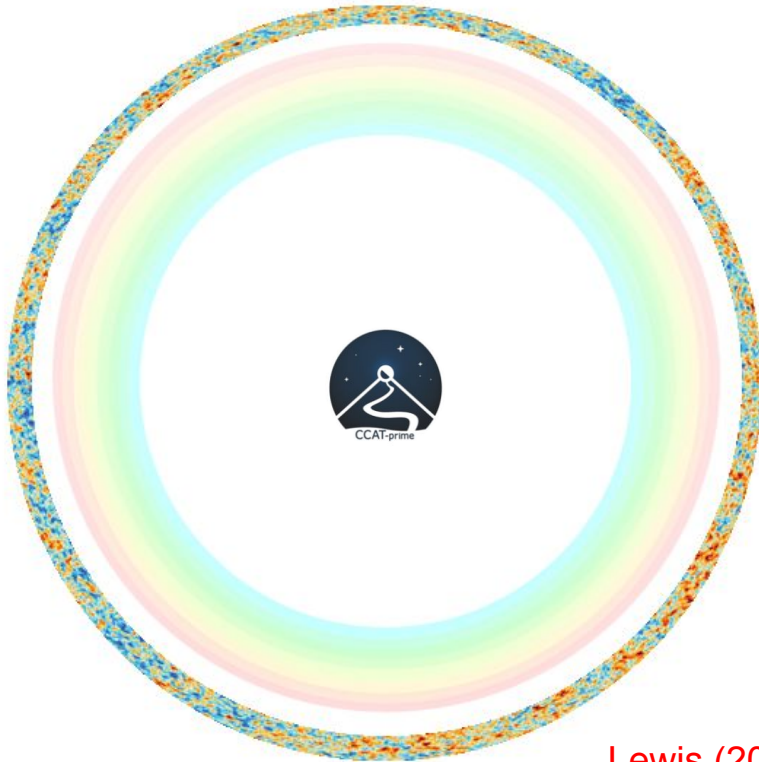
- Scattering by free electrons just prior to recombination
- Produces primary CMB
- Frequency independent -> same CMB fluctuation spectrum at all frequencies

Rayleigh Last Scattering



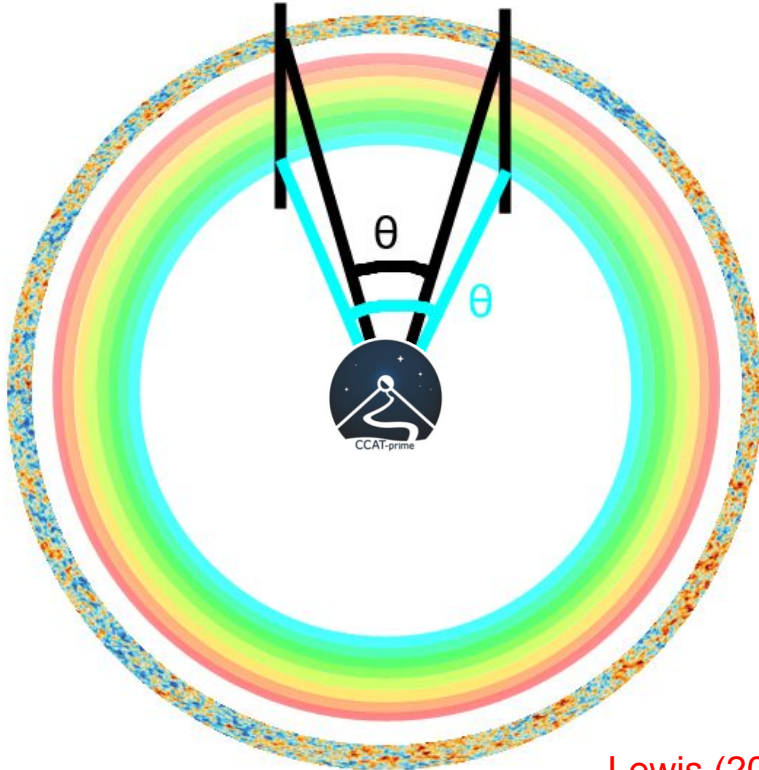
- Scattering by neutral hydrogen just after recombination
- ν^4 frequency dependence makes hot spots redder and cold spots bluer but does not change monopole
- Different last scattering surface and fluctuation spectrum for each frequency

Benefits of Rayleigh Scattering: Scatterer Density



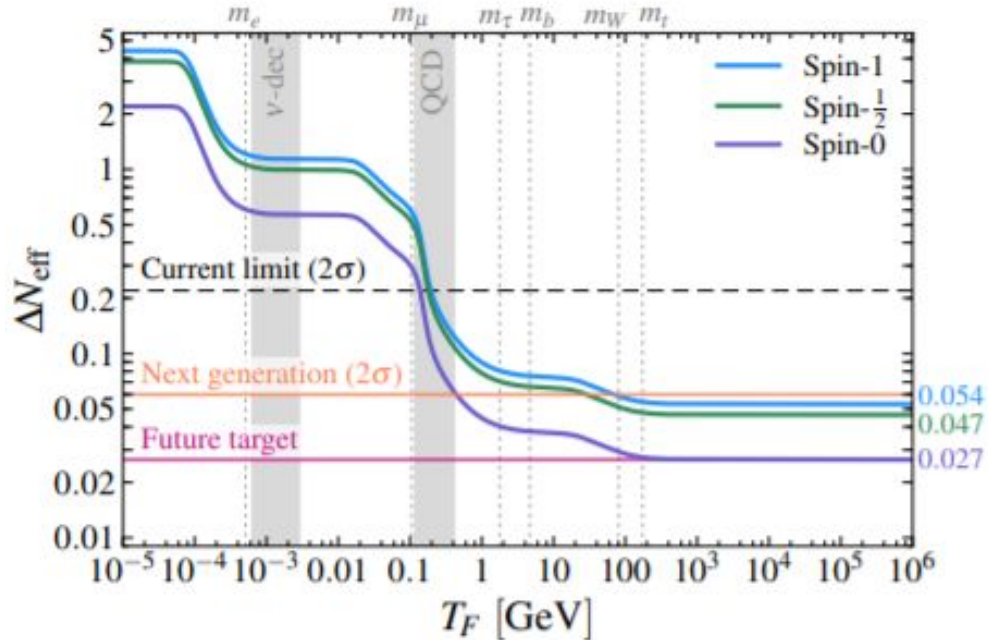
- Amplitude of Rayleigh scattering signal scales with neutral hydrogen density
- Increasing primordial helium density reduces Rayleigh scattering effect
- Constraints on new physics like milli-charged dark matter can also be improved

Benefits of Rayleigh Scattering: Measuring Lengths



- Fixed length scales appear at different angular scales for primary and Rayleigh scattered components of CMB
- Ratio of these angular scales can better constrain parameters
- Improves constraints on θ_s (H_0), N_{eff} , $\Omega_c h^2$, etc.

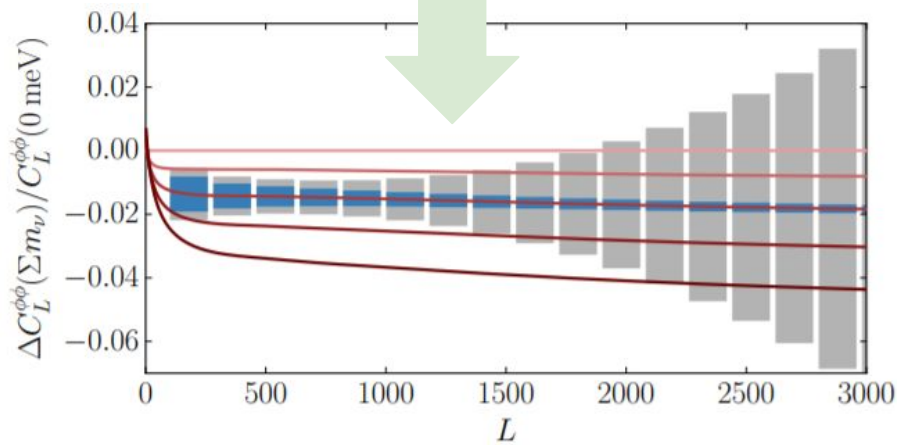
Example: Light Relics (N_{eff})



- Even modest improvements in constraints on N_{eff} are extremely valuable
- The scale of new physics to which we are sensitive is a very non-linear function of the error on N_{eff}
- Due to exponential damping of small scales, it is expensive to improve N_{eff} constraints by other means

Example: Degeneracy Breaking for M_ν

M_ν and Ω_c



- Both neutrino mass and the dark matter density affect the amplitude of the lensing power spectrum
- Planned CMB surveys rely on BAO measurements (from DESI) to break the degeneracy
- Rayleigh scattering allows for detection of minimal neutrino mass using only the CMB