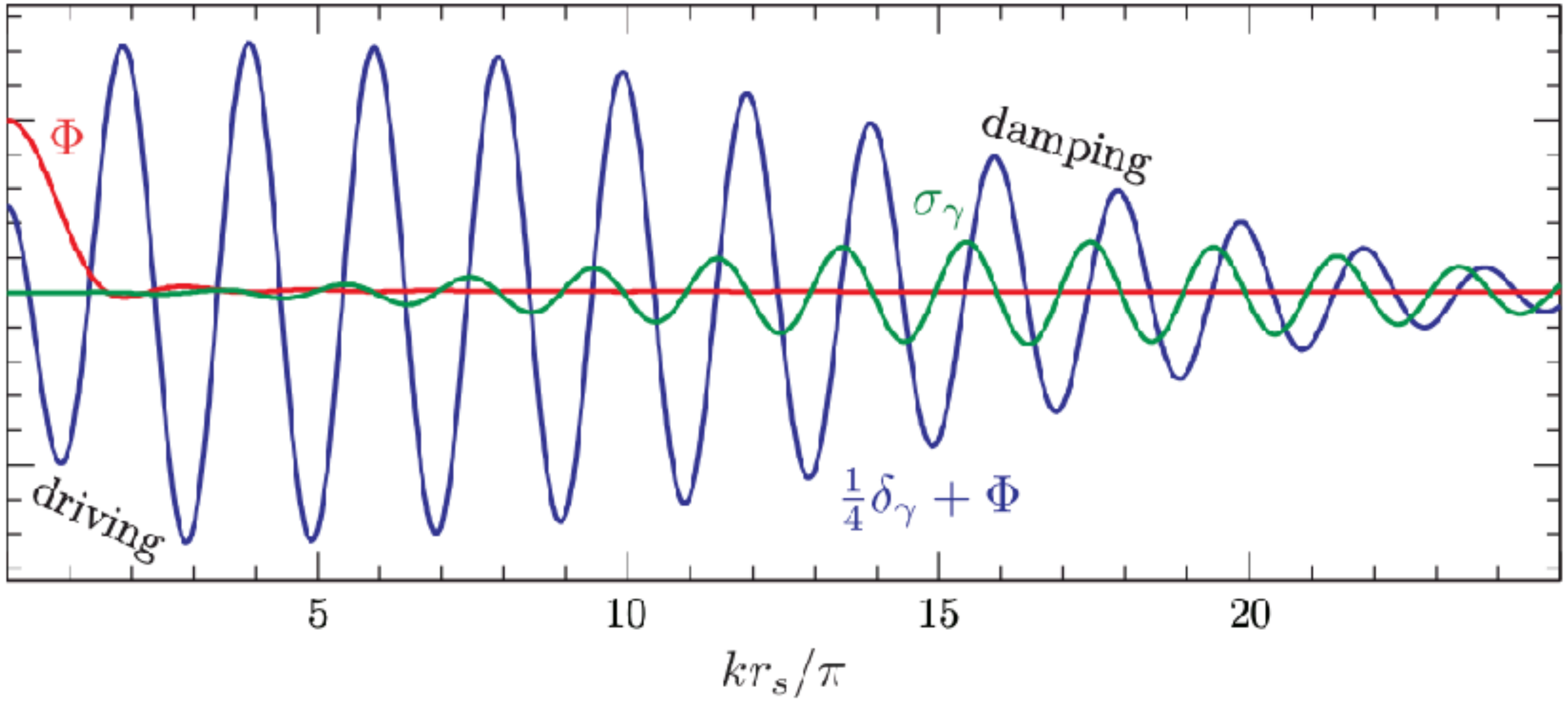
Cosmology and Particle Theory

Lecture 3

Jay Hubisz

Radiation Driving

Enhancing oscillations



Features in the CMB

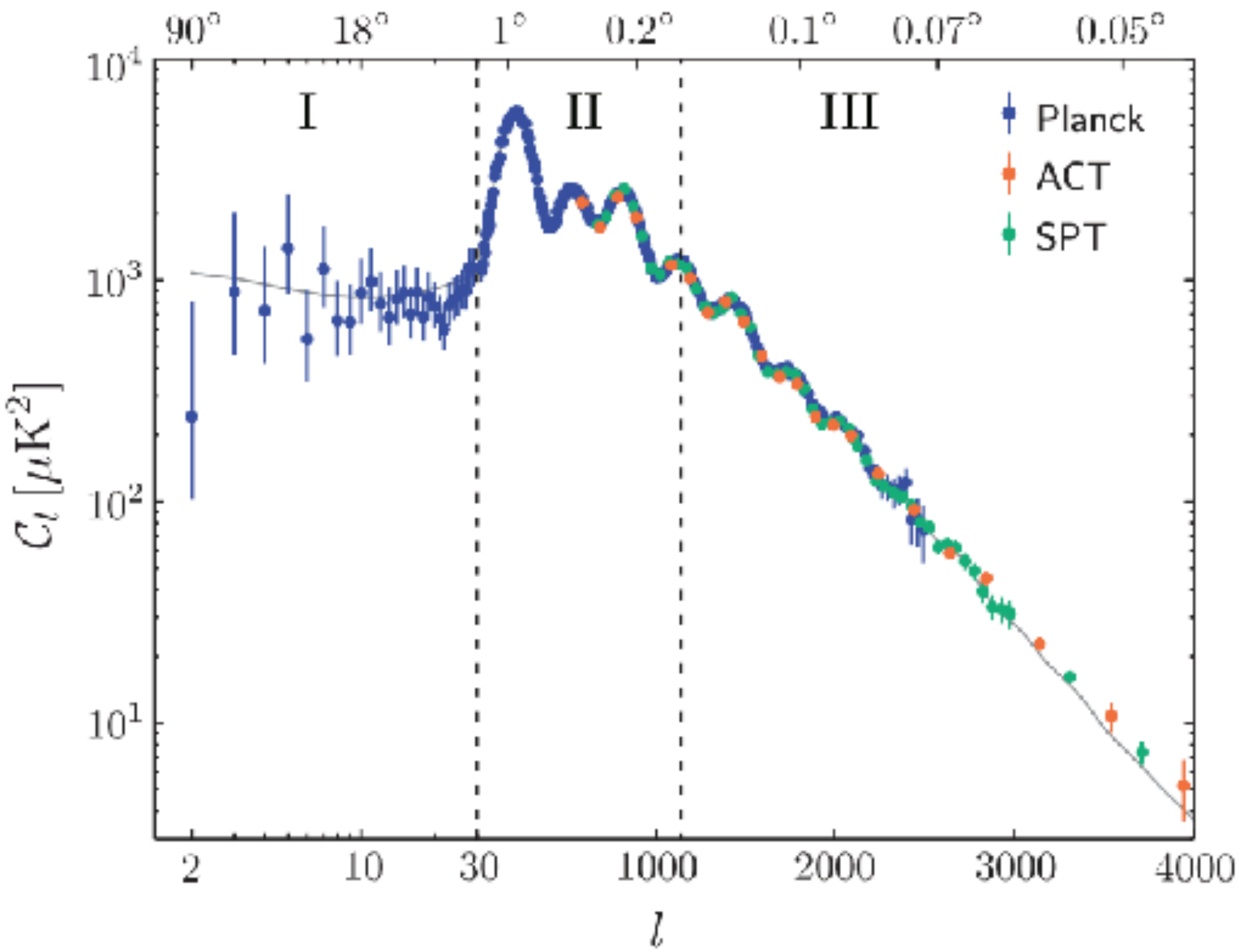
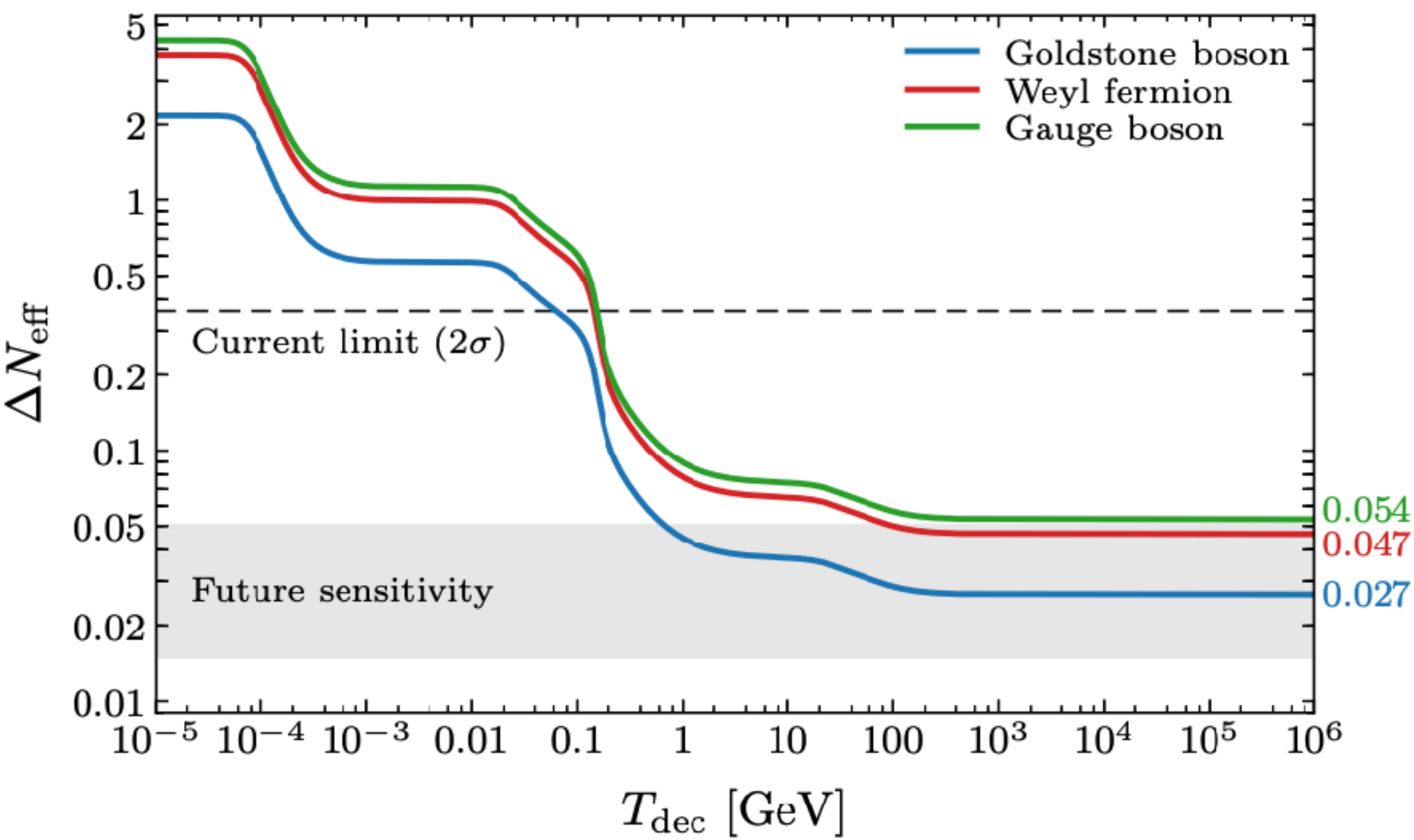


Figure 9. The angular variations of the CMB power spectrum are consequence of the dynamics of sound waves in the photon-baryon fluid. On large scales (region I), the fluctuations are frozen and we directly see the spectrum of the initial conditions. At intermediate scales (region II), we observe the oscillations of the fluid as captured at the moment of last-scattering. Finally, on small scales (region III), fluctuations are damped because their wavelengths are smaller than the mean free path of the photons.

Contribution to $\Delta N_{\rm eff}$

Different types of new light particle



N_{eff} and the CMB

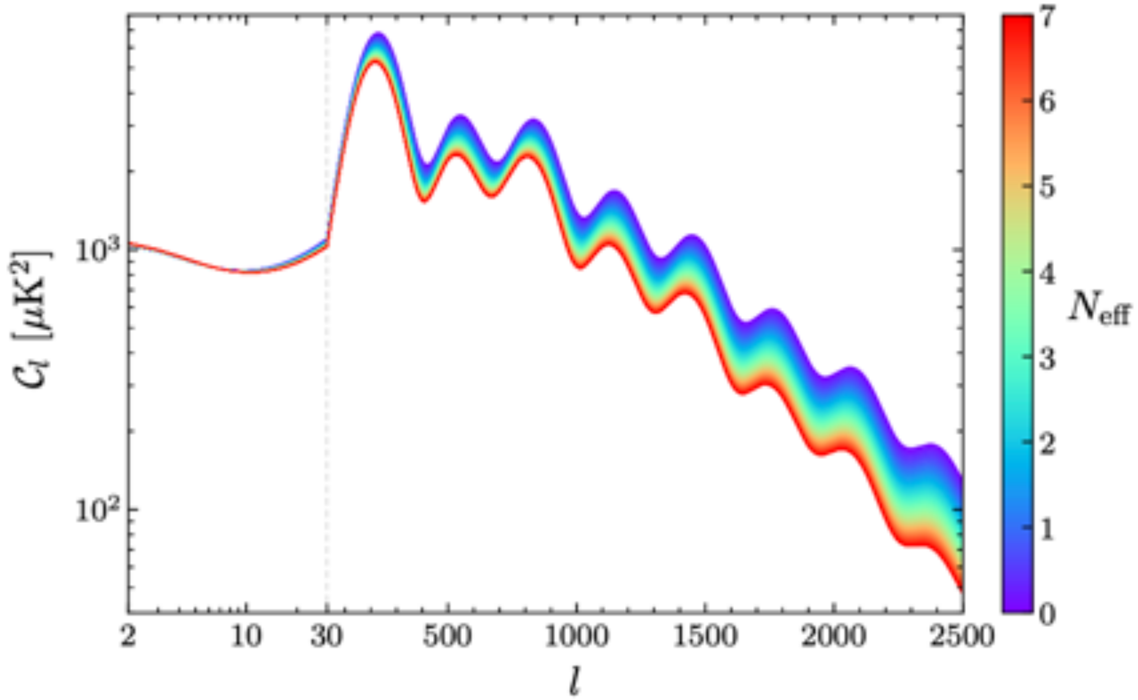


Figure 12. Variation of the CMB spectrum $\mathcal{C}_l \equiv l(l+1)C_l$ as a function of N_{eff} for fixed θ_*.

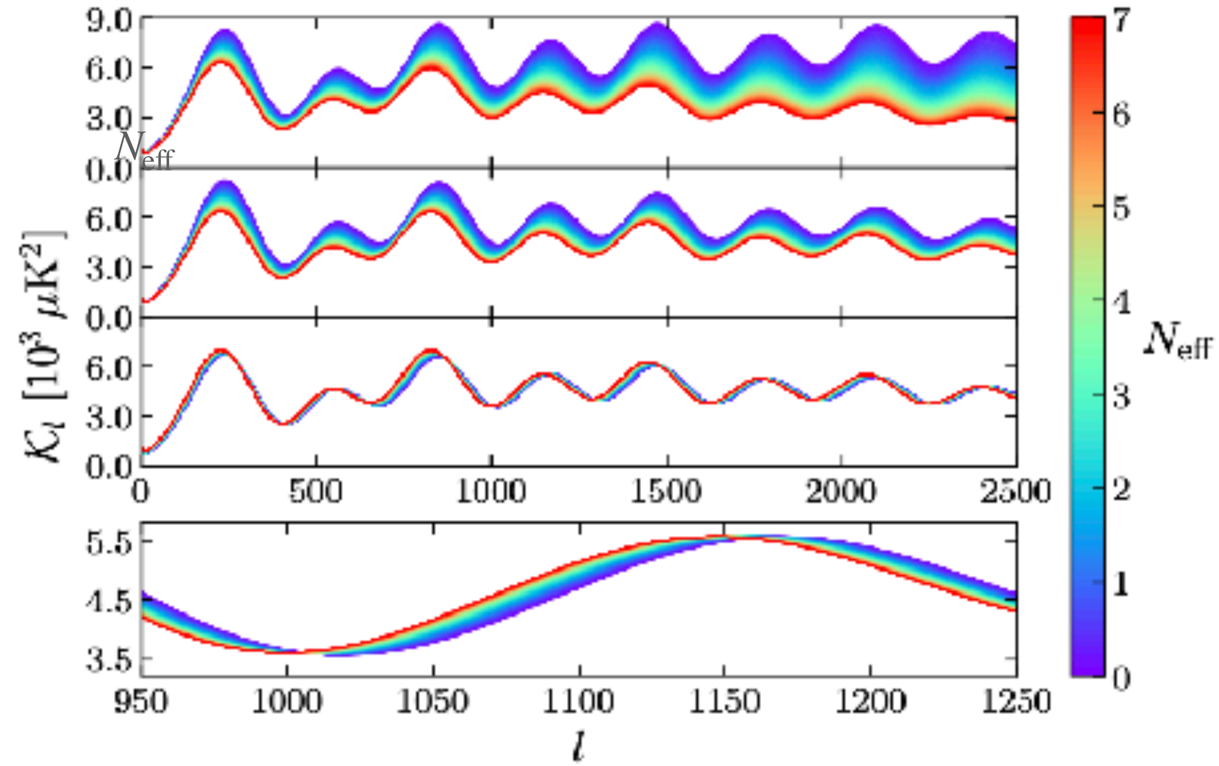


Figure 13. Variation of the undamped power spectra, $\mathcal{K}_l = \mathcal{D}_l^{-1}\mathcal{C}_l$, as a function of N_{eff}. The physical baryon density ω_b, the matter-to-radiation ratio ρ_m/ρ_r and the angular size of the sound horizon θ_* are held fixed in all panels. The dominant effect in the first panel is the variation of the damping scale θ_D. In the second panel, we fixed θ_D by adjusting the Helium fraction Y_P. The dominant variation is now the amplitude perturbation δA. In the third panel, the spectra are normalized at the fourth peak. The remaining variation is the phase shift φ (see the zoom-in in the fourth panel).

Planned Experimental Efforts

This looks outdated?

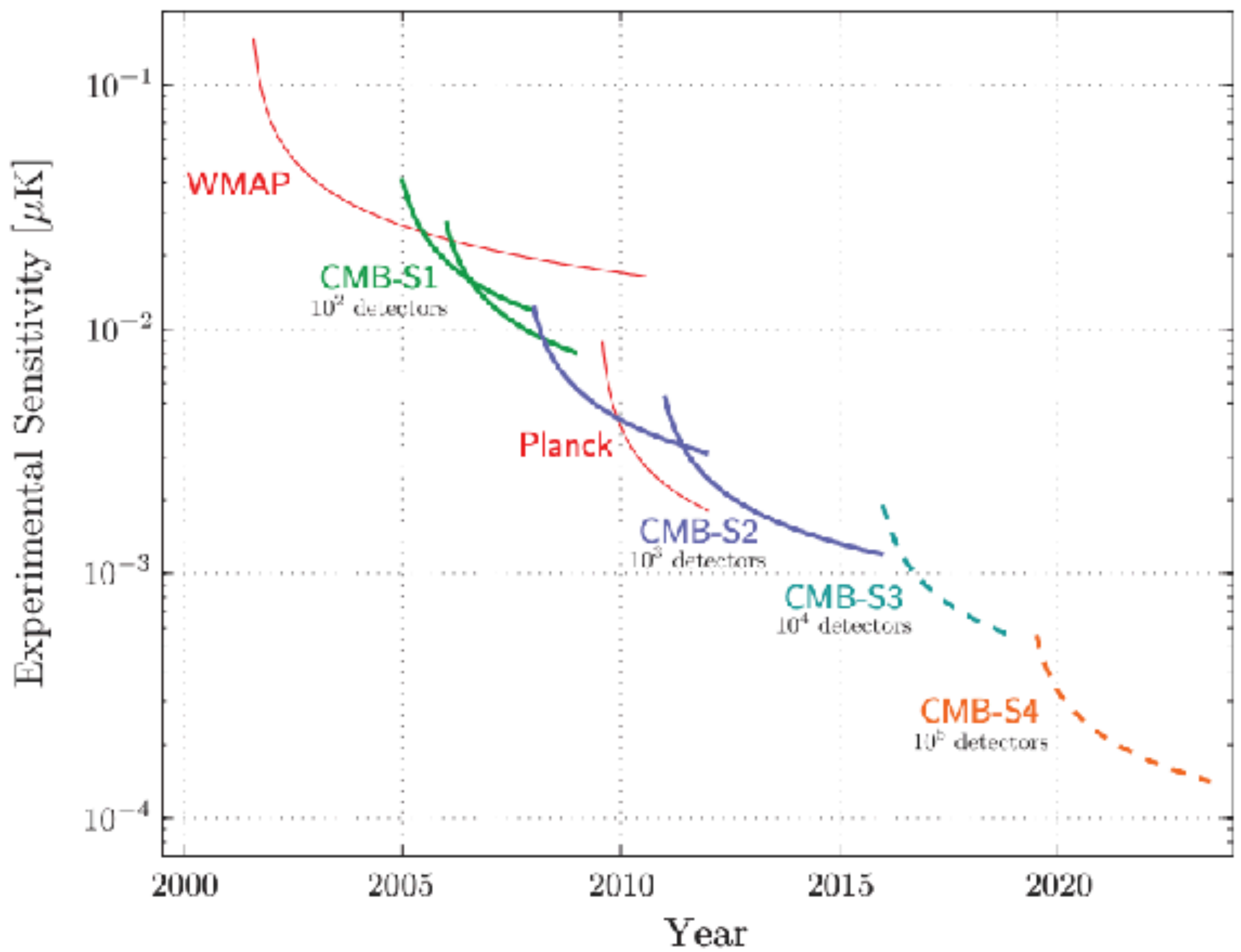
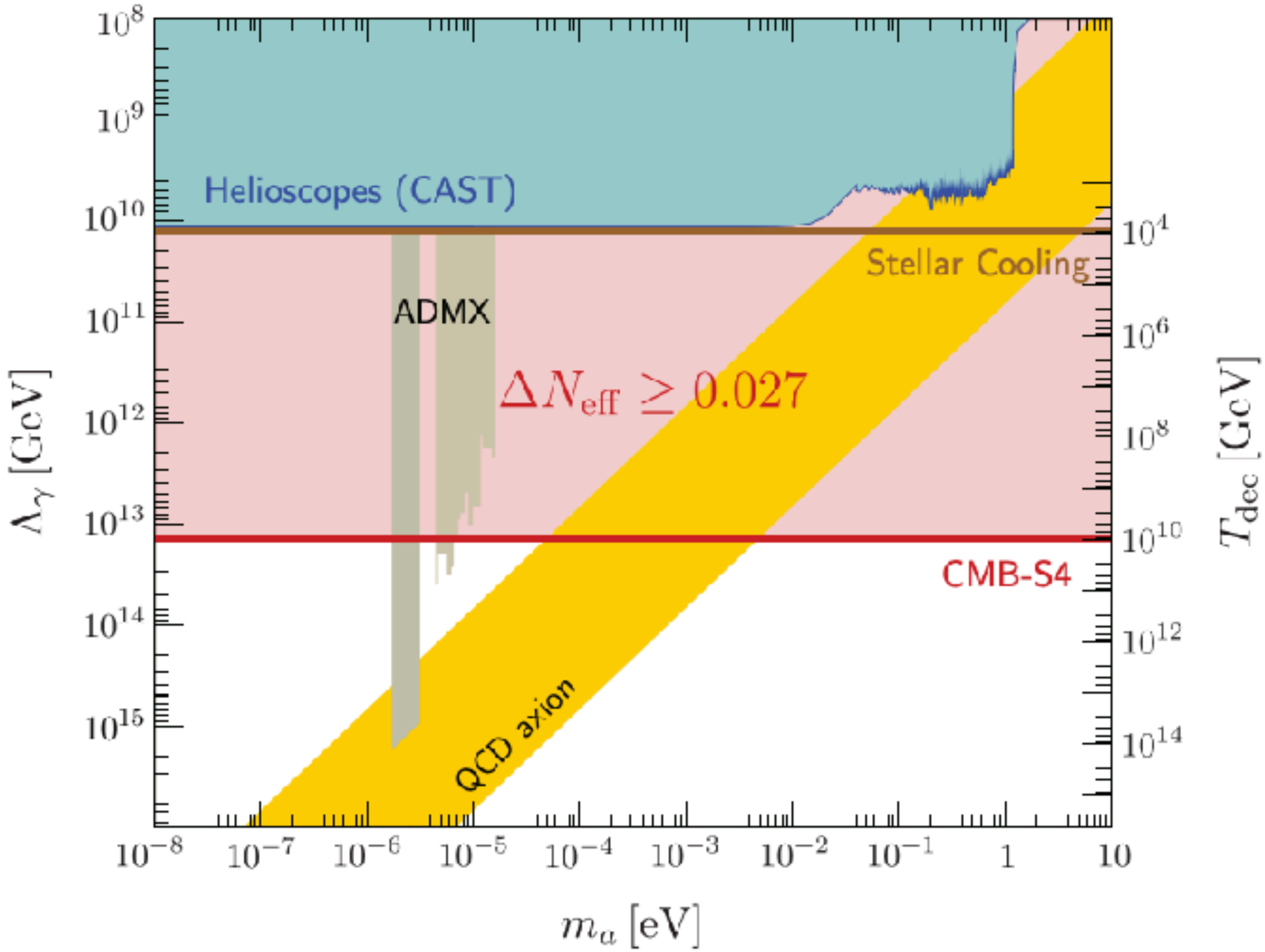


Figure 14. Evolution of the sensitivity of past and future CMB experiments (figure adapted from [19]).

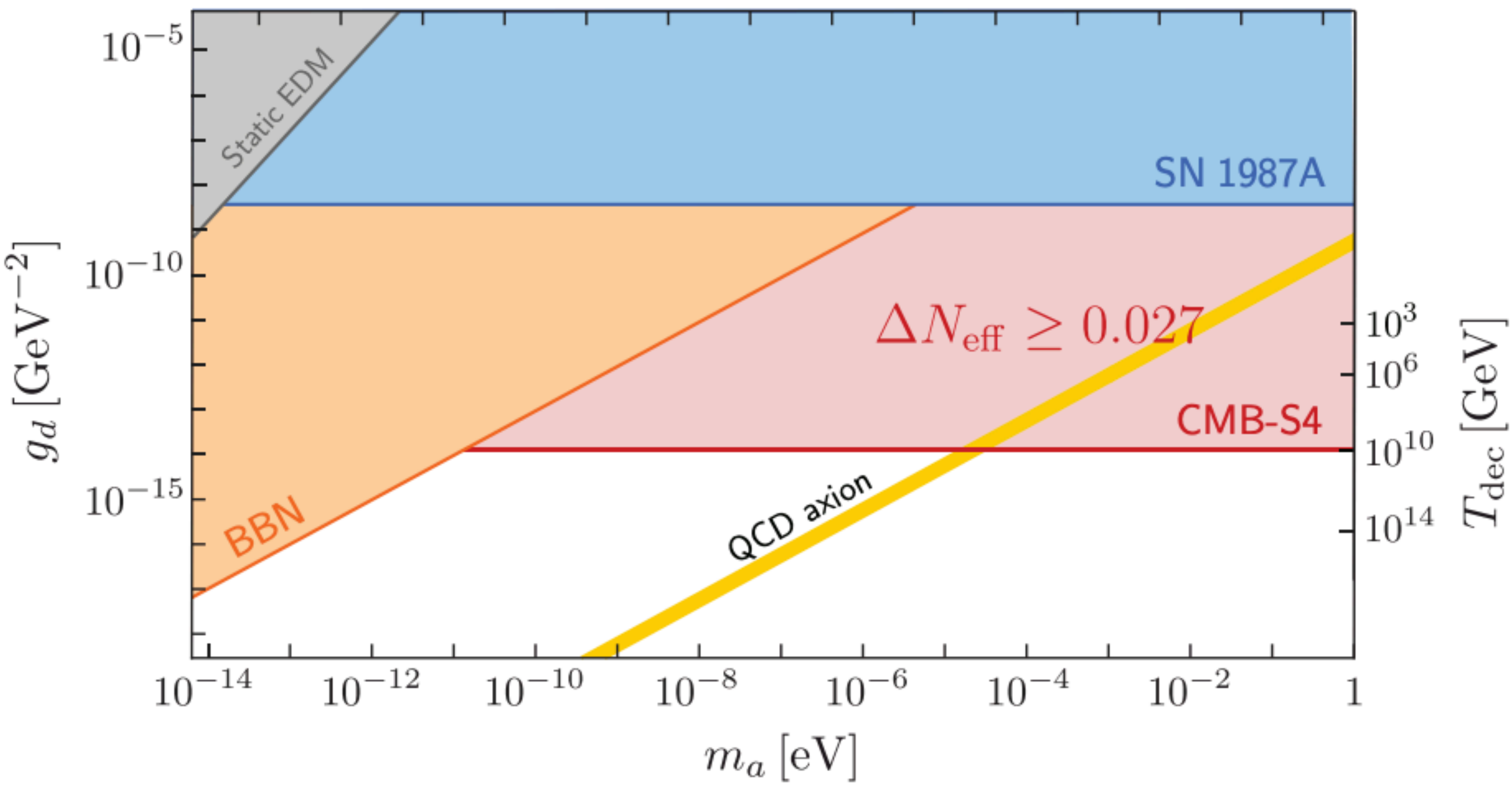
Constraints on the axion decay constant

Photon coupling: Some require axion DM



Constraints on the axion decay constant

Gluon coupling: Some require DM



Other relativistic hypotheticals are left as an exercise for the student…