THE UNIVERSITY OF EDINBURGH

The impact of baryons on dark energy measurements

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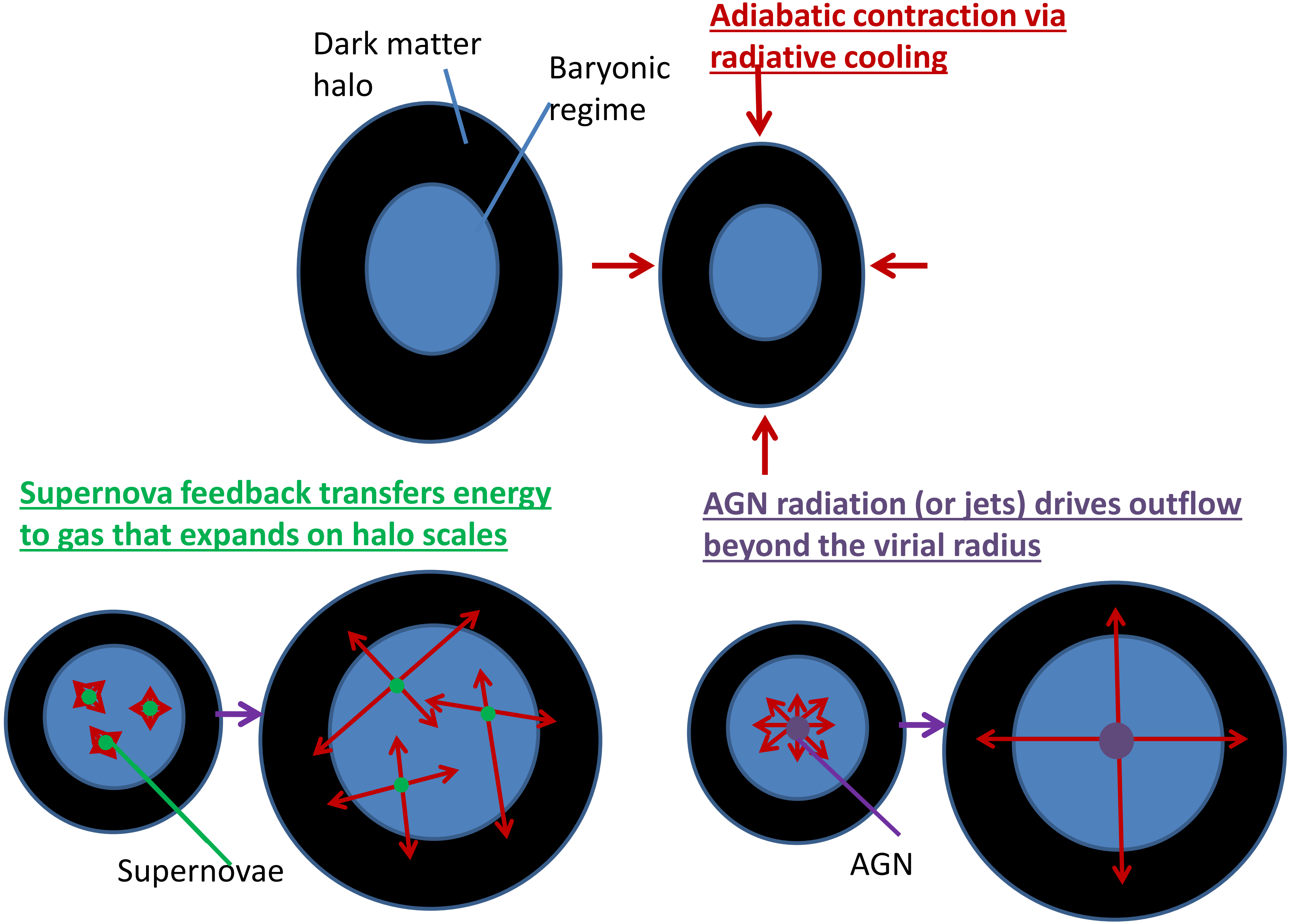
Baryon impact on matter distribution



Adiabatic contraction via radiative cooling

Supernova feedback transfers energy to gas that expands on halo scales

AGN radiation (or jets) drives outflow beyond the virial radius

Adiabatic contraction captured by modifying concentrations

NFW profile

1) A_B controls the amplitude of the halo profile via the concentration factor (Mead et al. 2015)

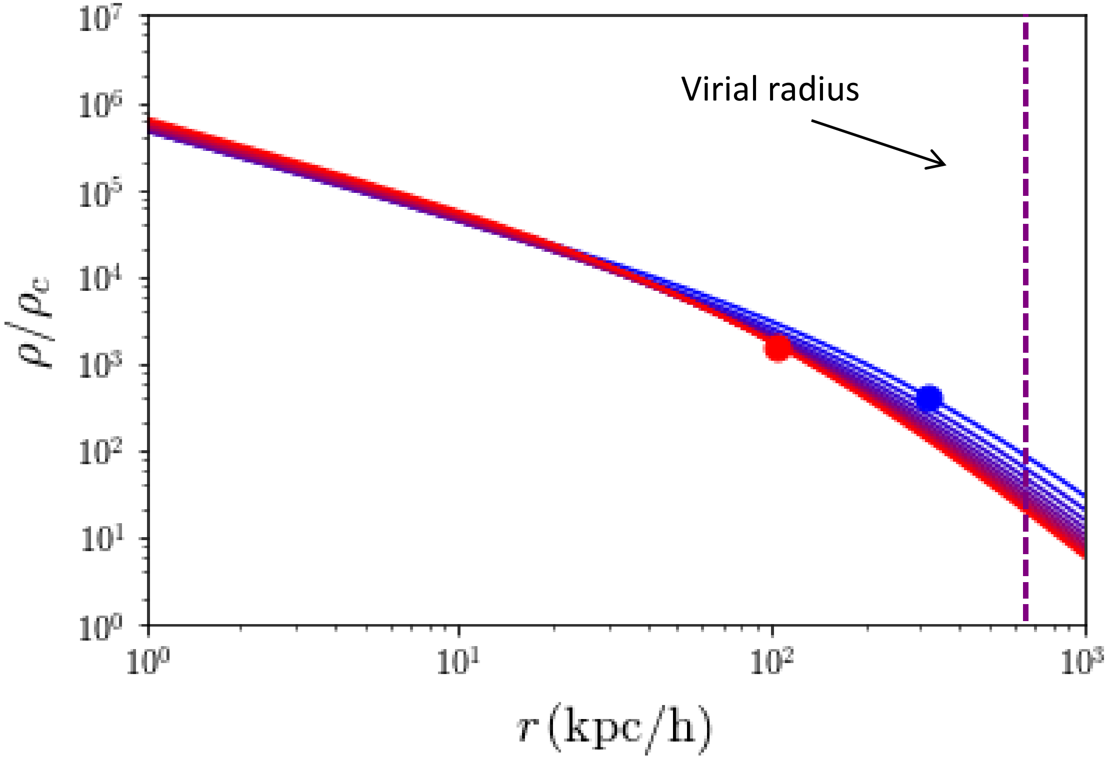
$$\rho\left(r\right)=\frac{\rho_N}{\frac{r}{r_s}\left(1+\frac{r}{r_s}\right)^2}$$

$$\downarrow$$

$$r_s=\frac{r_v}{c}$$

$$\downarrow$$

$$c\left(M,z\right)=A_B\left(\frac{1+z_f}{1+z}\right)$$



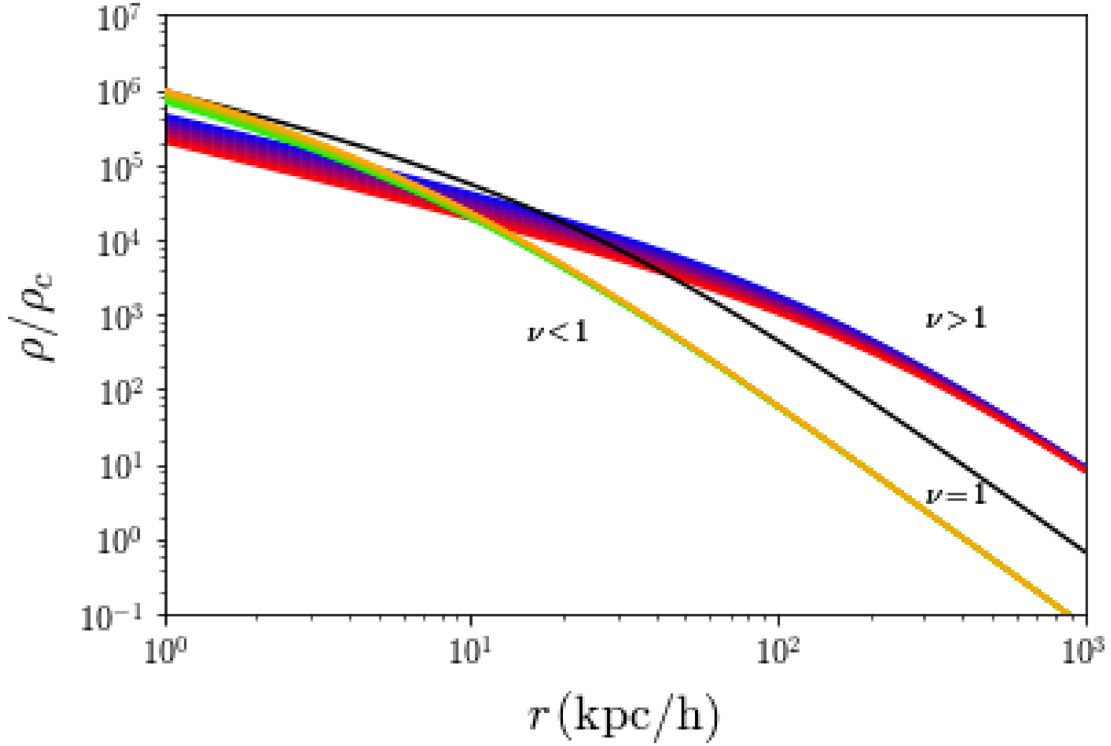
Bluer (redder) lines correspond to lower (higher) A_B

Impact of feedback varies over scale and mass

2) η_0 introduces a **mass-dependent** modification of the halo shape (Mead et al, 2015)

$$\Delta^2_{1h}(k) = \frac{k^3}{2\pi^2}\int_0^\infty M^2\, W^2(k,M)\, F(M)\, \mathrm{d}M \qquad W(k,M) = \int_0^{r_v} r^2\, \frac{\sin(kr)}{kr}\rho(r,M)\, \mathrm{d}M$$

$$W(k,M) \rightarrow W(\nu^\eta k, M) \qquad \nu = \frac{\delta_c}{\sigma(M)} \qquad \eta = \eta_0 - 0.3\sigma_8(z)$$

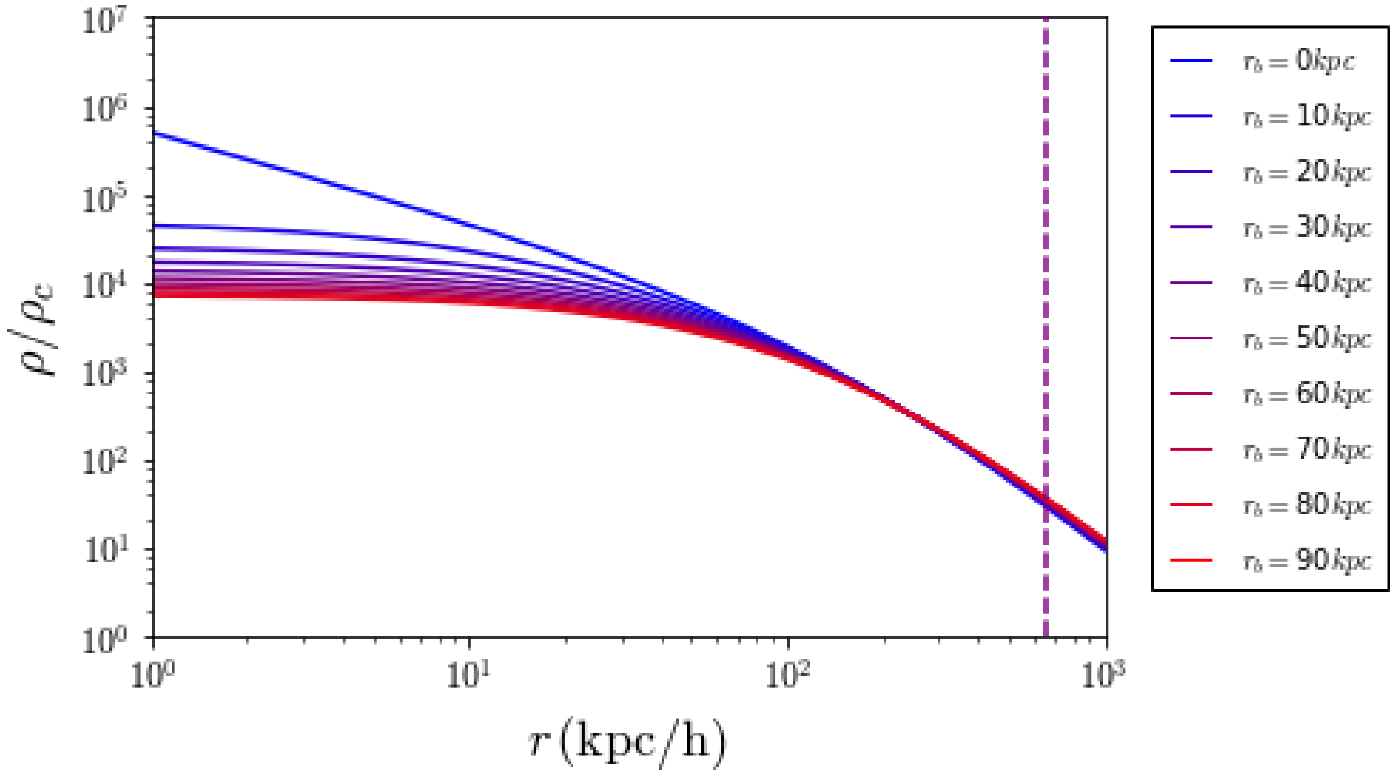


High mass halo: bluer (redder)⟷ lower (higher) η_0
Low mass halo: green (orange) ⟷ lower (higher) η_0

Small-scale physics captured by parameterising an inner core

3) Baryon-induced (or via e.g. axions) inner core introduces a second break scale, r_b

$$\rho\left(r\right) = \frac{\rho_N}{\left(\frac{r_b}{r_s} + \frac{r}{r_s}\right)\left(1 + \frac{r}{r_s}\right)^2}$$

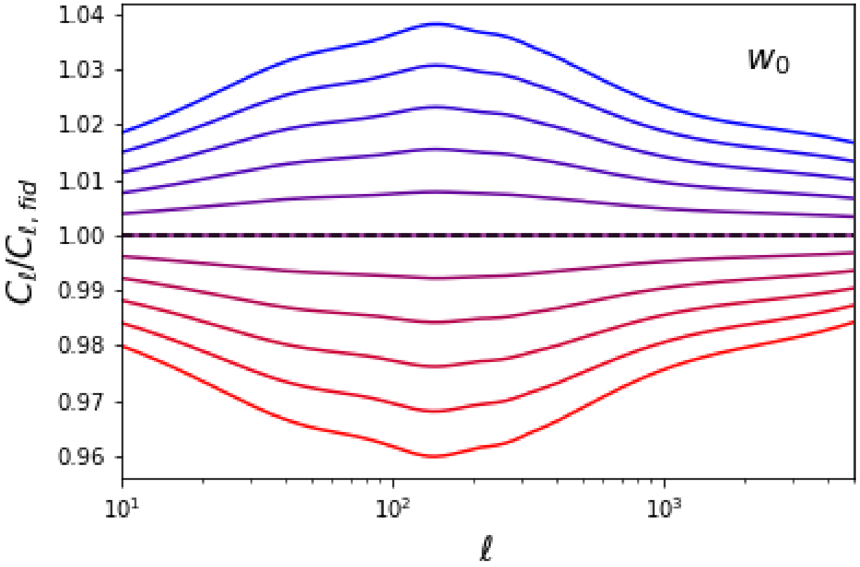


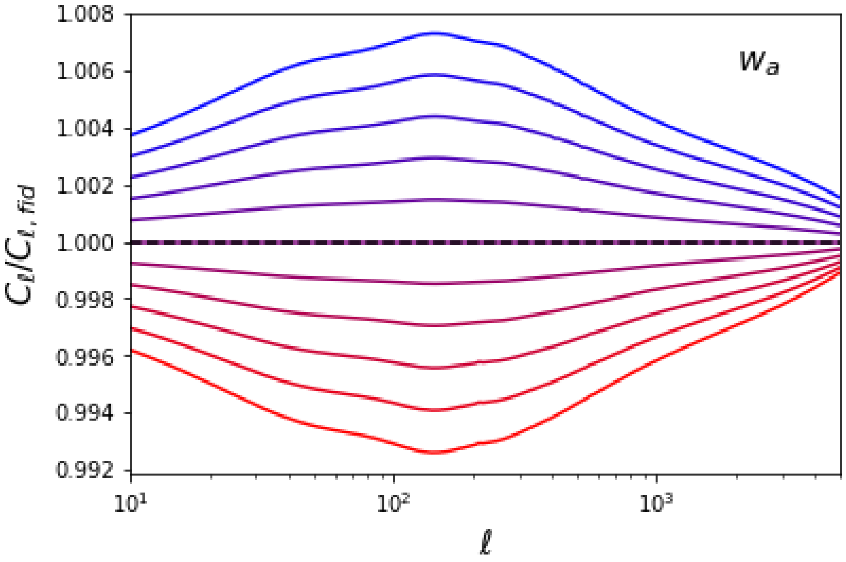
Dark energy influence on convergence power spectrum

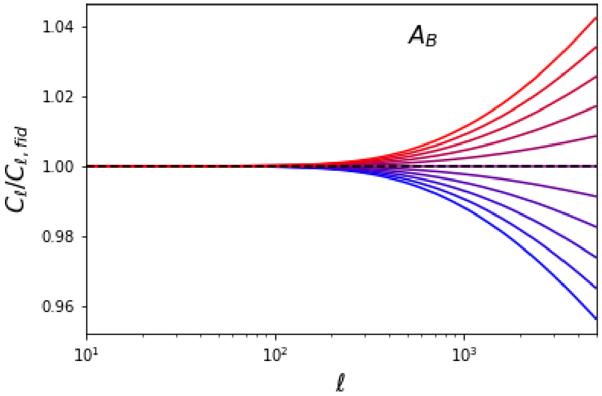
$$w\,(a) = w_0 + (1-a)\,w_a$$

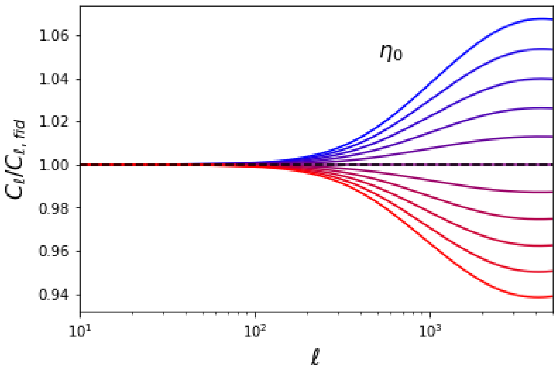
$$w = \frac{P}{\rho} < -\frac{1}{3}$$

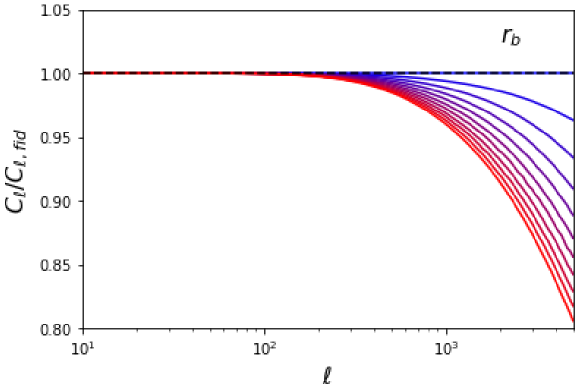
Θ	Θ_{min}	Θ_{max}	Θ_{fid}
w_0	-1.1	-0.9	-1.
w_a	-0.1	0.1	0.



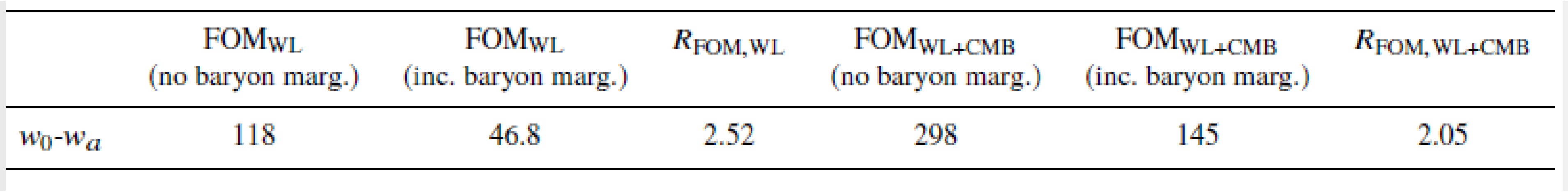




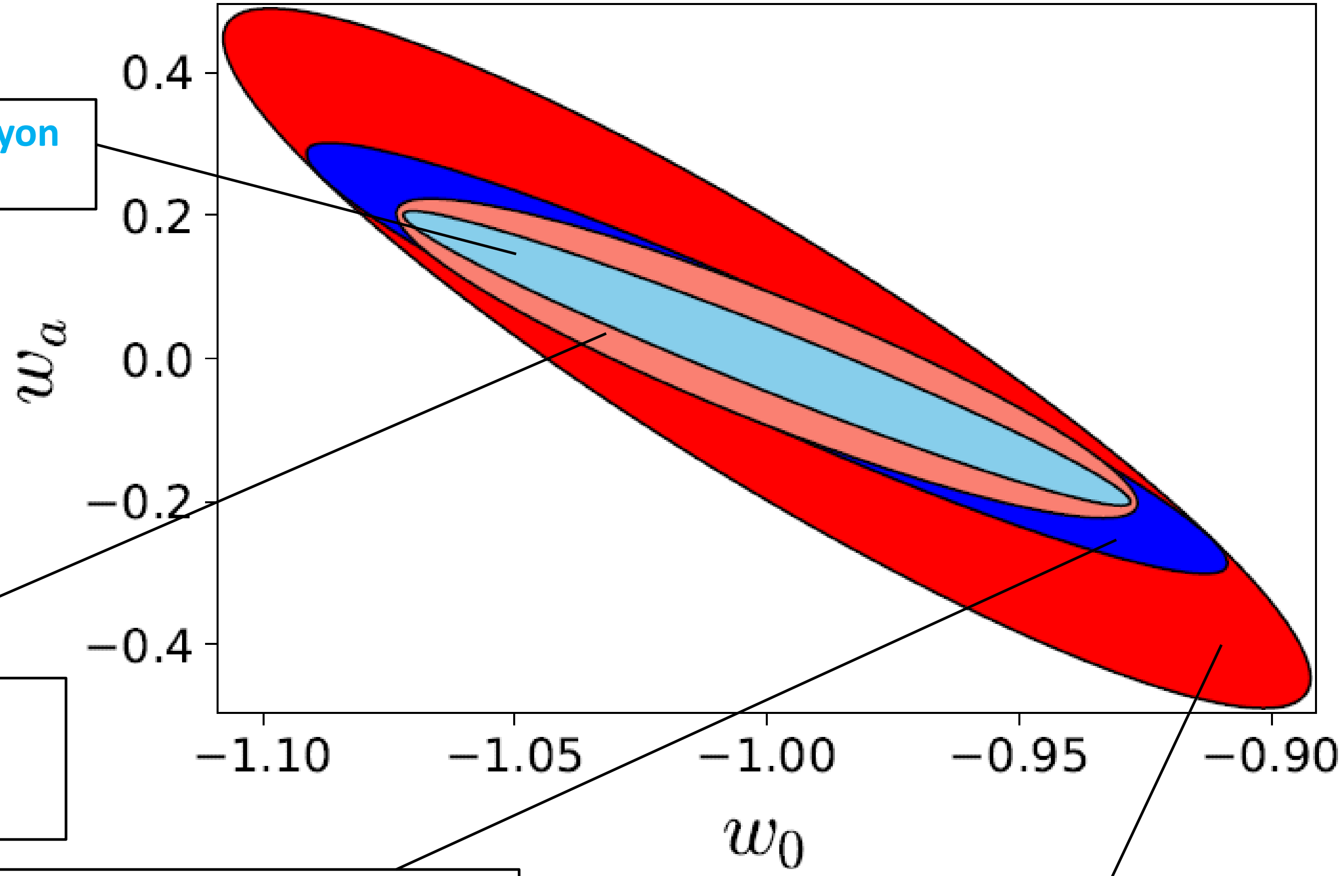




Adding Planck CMB priors substantially improves errors on w_0 and w_a, but relative degradation to FOM remains



	$\mathrm{FOM}_{\mathrm{WL}}$ (no baryon marg.)	$\mathrm{FOM}_{\mathrm{WL}}$ (inc. baryon marg.)	$R_{\mathrm{FOM,WL}}$	$\mathrm{FOM}_{\mathrm{WL+CMB}}$ (no baryon marg.)	$\mathrm{FOM}_{\mathrm{WL+CMB}}$ (inc. baryon marg.)	$R_{\mathrm{FOM,WL+CMB}}$
w_0-w_a	118	46.8	2.52	298	145	2.05



Planck CMB priors + all baryon parameters fixed

Planck CMB priors + all baryon effects marginalised over

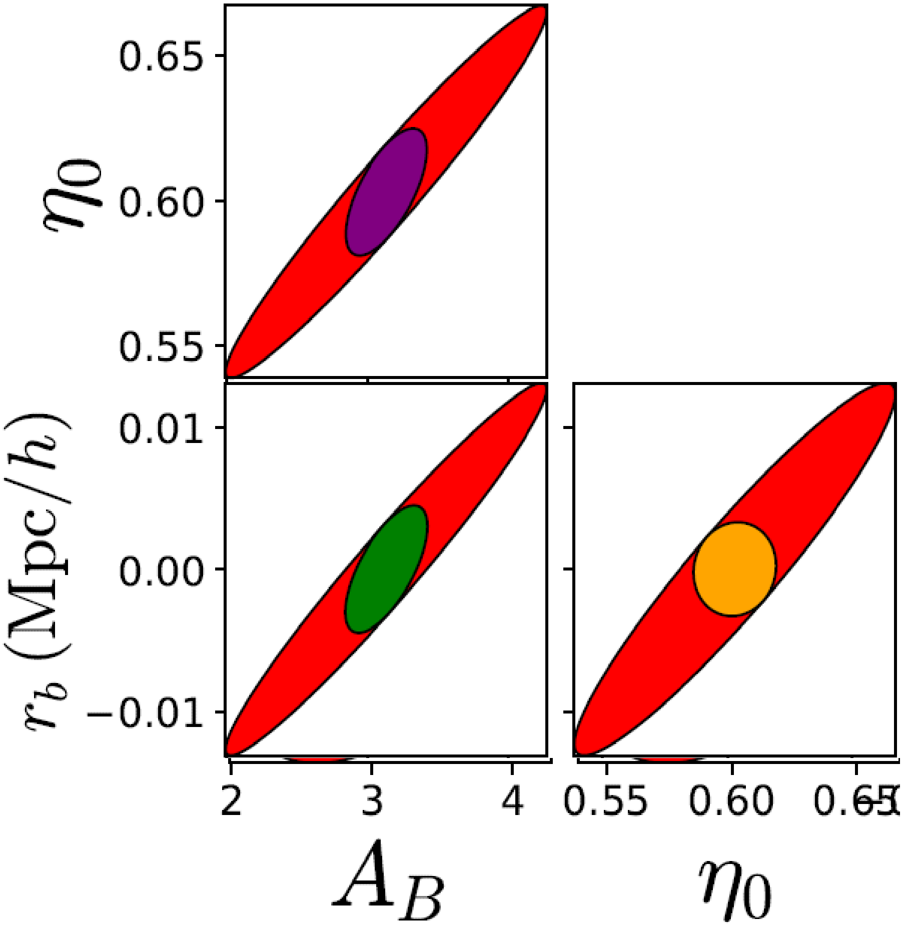
All baryon parameters fixed

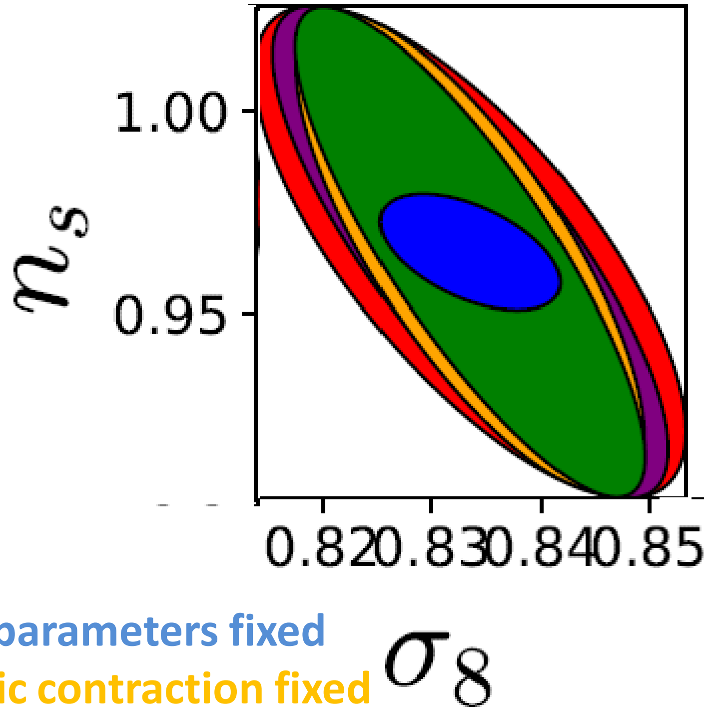
All baryon effects marginalised over

Other key results:

1) Cosmological parameters are also significantly impacted

2) Baryon parameters can also be constrained to provide – but are affected at an order of magnitude level by including the inner core





Baryon parameters fixed
Adiabatic contraction fixed
Baryonic feedback fixed
Inner core fixed
All baryon parameters marginalised over

Summary

- Baryons affect the power spectrum at the percent level.
- Generic baryon-halo model can be used to investigate impact on forecasts from baryon and cosmological effects
- **60% impact for dark energy Figure of Merit for LSST.**
- Substantial improvements are available through external priors from the CMB
- More drastic effect on forecasts of cosmological parameters like n_s and σ_8
- Can constrain (to a degree) baryon effects themselves from future surveys.