Doctoral School in Science and High Technology
Course of Physics and Astrophysics

Weak lensing signal in Unified Dark Matter models

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Stefano Camera[1,2]

in collaboration with **D. Bertacca**, **A. Diaferio**, **N. Bartolo** and **S. Matarrese**

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School of Astrophysics "Francesco Lucchin"
Bertinoro, May 24-29, 2009

Outline

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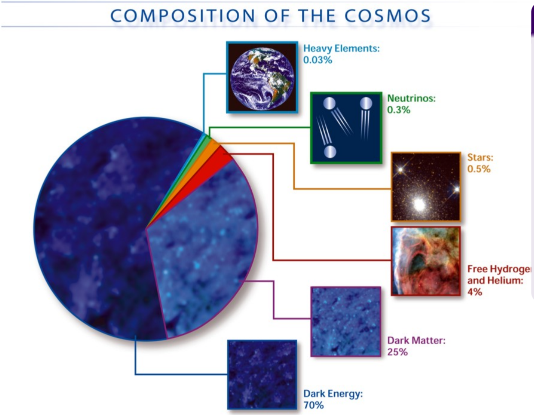
Unified Dark Matter models

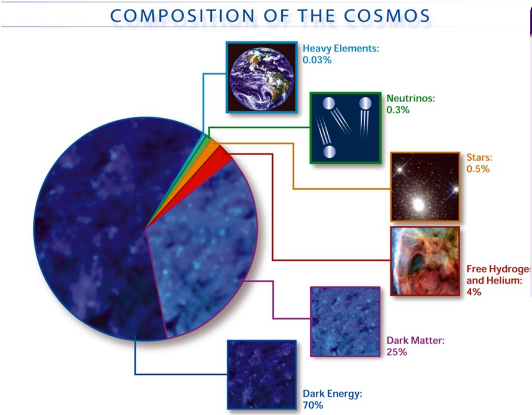


UDM

Only one exotic component, a scalar field $\varphi(t, \mathbf{x})$ that can mimic both DM and DE, i.e.

$$\rho\left[a(t)\right] = \underbrace{\rho_{\mathrm{DM}}}_{\propto a^{-3}} + \overbrace{\rho_{\Lambda}}^{\mathrm{const.}}$$

Unified Dark Matter models



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- $k-$inflation[a]
- expansion history, ISW effect, halos of “UDM”[b]

[a] Armendariz-Picon et al. (1999), Kamenshchik et al. (2001), Bilic et al. (2002), Scherrer (2004)

[b] Bertacca & Bartolo (2007), Bertacca et al. (2008)

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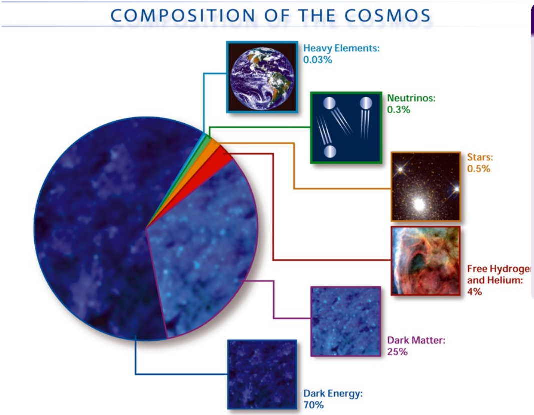

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UDM prediction of weak gravitational lensing by LSS

[a] Armendariz-Picon et al. (1999), Kamenshchik et al. (2001), Bilic et al. (2002), Scherrer (2004)

[b] Bertacca & Bartolo (2007), Bertacca et al. (2008)

$$\mathrm{d}s^2 \equiv g_{\mu\nu}\mathrm{d}x^\mu \mathrm{d}x^\nu = a^2(\tau)\left[-(1+2\mathbf{\Phi})\mathrm{d}\tau^2 + (1-2\mathbf{\Phi})\mathrm{d}\ell^2\right]$$

Equation for scalar perturbation in linear theory

$$v'' - {c_s}^2\nabla^2 v - \frac{\theta''}{\theta}v = 0$$

- $v \propto \mathbf{\Phi}$
- ${c_s}^2 = \frac{p_{,X}}{p_{,X} + 2Xp_{,XX}}$ is the speed of sound of the scalar field

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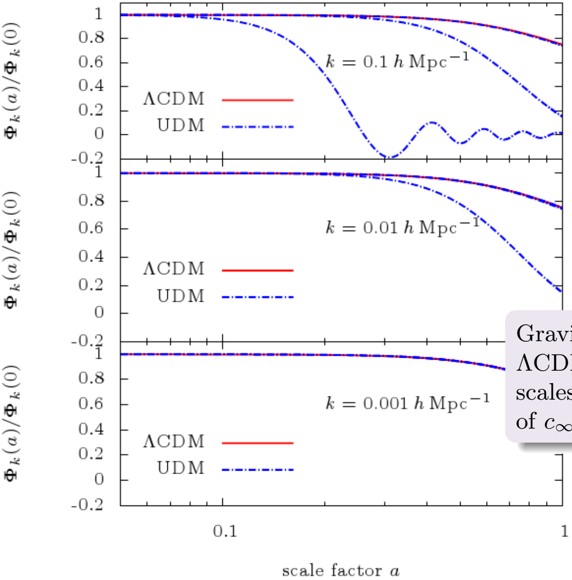
EQUATION FOR SCALAR PERTURBATION IN LINEAR THEORY

$$v'' - {c_s}^2\nabla^2 v - \frac{\theta''}{\theta}v = 0$$

- $v \propto \boldsymbol{\Phi}$
- ${c_s}^2 = \frac{\Omega_\Lambda {c_\infty}^2}{\Omega_\Lambda + (1-{c_\infty}^2)\Omega_m a^{-3}}$ is the speed of sound of the scalar field
  $c_\infty \equiv c_s(a \to \infty)$



(SC et al. 2009)

Gravitational potentials for ΛCDM and UDM at different scales and for different values of $c_\infty = 10^{-3}, 10^{-2}, 10^{-1}$.

Results

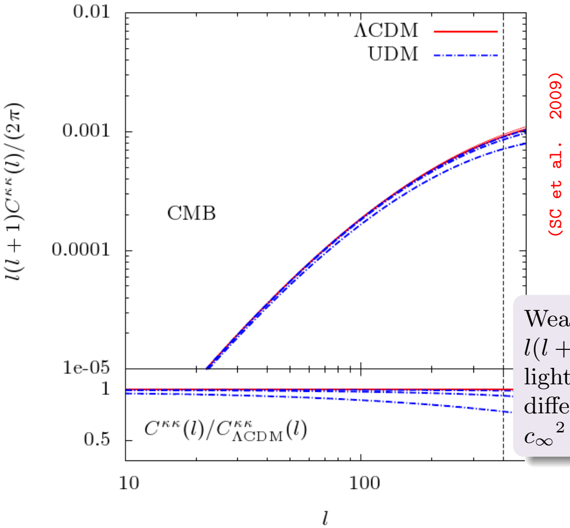
Convergence power spectrum

$$C^{\kappa\kappa}(l)=\frac{l^4}{4}\int_0^\infty \mathrm{d}\chi\,\frac{W^2\left(\chi,n(\chi)\right)}{\chi^6}P^{\mathbf{\Phi}}\left(\frac{l}{\chi},\chi\right)$$

Assumptions

1. $h=0.72$, $\Omega_m=0.26$ and $\Omega_\Lambda=0.74$
2. BBKS transfer function (Bardeen et al. 1986)
3. Peacock & Dodds (Peacock & Dodds 1996) linear to non-linear mapping

$$n_{\text{CMB}}\left[\chi(z)\right]=\delta_D\left(\chi(z)-\chi(z_{\text{rec}})\right)$$

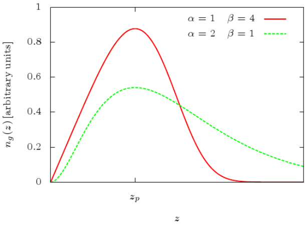


$z_p \equiv z_{\text{rec}} = 1000$

Weak lensing power spectra $l(l+1)C^{\kappa\kappa}(l)/(2\pi)$ of CMB light for ΛCDM and UDM for different values of ${c_\infty}^2=10^{-6}$, 10^{-5}, 10^{-4}.

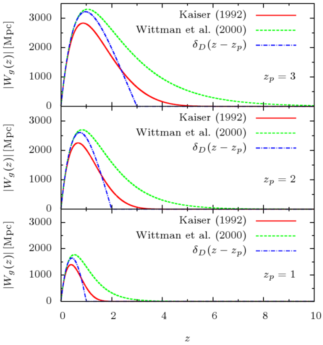
The redshift distribution of sources is (Kaiser 1992)

$$n_g\left[\chi(z)\right]=\frac{\beta z^\alpha}{{z_0}^{\alpha+1}}\frac{e^{-\left(\frac{z}{z_0}\right)^\beta}}{\Gamma\left(\frac{\alpha+1}{\beta}\right)}\frac{\mathrm{d}z}{\mathrm{d}\chi}$$



(SC et al. 2009)

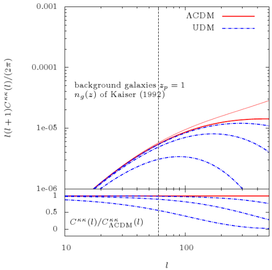
Redshift distribution of galaxies $n_g(z)$.



(SC et al. 2009)

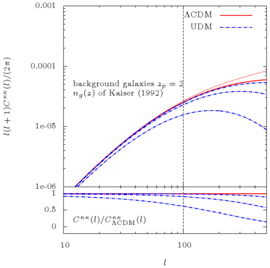
Weight functions $W_g(z)$ for different $n_g(z)$ and z_p.

(SC et al. 2009)



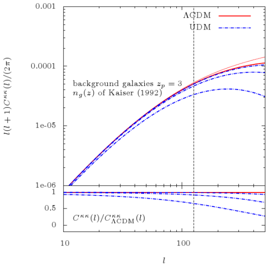
α	$=$	1
β	$=$	4
z_p	$=$	1

(SC et al. 2009)



α	$=$	1
β	$=$	4
z_p	$=$	2

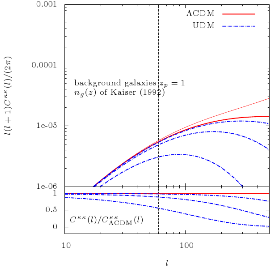
(SC et al. 2009)



α	$=$	1
β	$=$	4
z_p	$=$	3

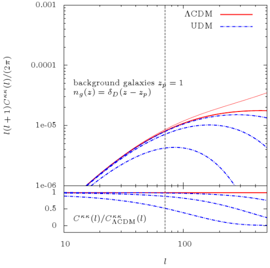
Weak lensing power spectra $l(l+1)C^{\kappa\kappa}(l)/(2\pi)$ of background galaxy light for ΛCDM and UDM for different values of ${c_\infty}^2 = 10^{-6}$, 10^{-5}, 10^{-4}.

(SC et al. 2009)



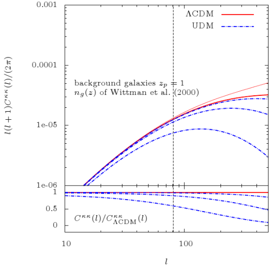
α	$=$	1
β	$=$	4
z_p	$=$	1

(SC et al. 2009)



α	$=$	$-$
β	$=$	$-$
z_p	$=$	1

(SC et al. 2009)



α	$=$	2
β	$=$	1
z_p	$=$	1

Weak lensing power spectra $l(l+1)C^{\kappa\kappa}(l)/(2\pi)$ of background galaxy light for ΛCDM and UDM for different values of ${c_\infty}^2 = 10^{-6}$, 10^{-5}, 10^{-4}.

Conclusions

When the Jeans' length of the Newtonian potential increases, $\mathbf{\Phi}_k(a)$ starts to decay earlier in time (for a fixed scale), or yet at greater scales (for a fixed epoch).

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Thanks!

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- $W\left(\chi,n(\chi)\right)=-2\chi\int_\chi^\infty \mathrm{d}\chi'\,\frac{\chi'-\chi}{\chi'}n(\chi')$ weight function of weak lensing
- $n\left[\chi(z)\right]$ redshift distribution of sources

Assumptions

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